Imperceptible Individuals: issues in the applications of social theory to Lower Palaeolithic material culture

FOULDS, FREDERICK,WILLIAM,FRANCIS

ABSTRACT

This thesis aims to explore whether idiosyncrasies in Acheulean handaxe manufacture can be seen and, if so, whether these can be used to trace the actions of hominins within the Lower Palaeolithic. This analysis has important implications for the application of current social theory to Palaeolithic contexts, which advocates a 'bottom-up' approach to archaeological study. This socially orientated theoretical approach emphasises the individual as the primary unit of analysis. However, as Hopkinson and White (2005) state, there is currently no methodology for such an analysis, rendering many discussions as exercises in what has been termed 'theoretical storytelling'.

Using a series of innovative experiments, the question of whether the individual is a viable unit of analysis was tested. The results show that a suite of other factors that also contribute to stone tool manufacture currently masks the actions of individuals. Chief amongst these is variability in the raw material nodules selected for reduction. However, intra-site variability may indicate differences that are linked to socially mediated knapping strategies, or 'group templates' (c.f. Ashton & McNabb 1994). While this possibility requires further exploration, the thesis suggests that the individual is currently not viable as a primary unit of analysis within Palaeolithic archaeology and stresses that the theories posited from the standpoint of the individual cannot be interpreted as fact. At the same time, it appears that further work needs to be conducted that focuses on the more traditional group as the primary analytical unit and the prospect of teasing apart the interplay between the individuals, groups and the effects of raw material variability.

IMPERCEPTIBLE INDIVIDUALS

ISSUES IN THE APPLICATIONS OF SOCIAL THEORY TO LOWER PALAEOLITHIC MATERIAL CULTURE

VOLUME I

Artist's rendition of the hominins and activities present at the site of Boxgrove, West Sussex (after Pitts & Roberts 1997 cover illustration)

FREDERICK FOULDS

DEPARTMENT OF ARCHAEOLOGY

SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DURHAM UNIVERSITY

MAY 2012

TABLE OF CONTENTS

VOLUME I

VOLUME II

DECLARATION

None of the material within this thesis has been previously submitted as part of a degree at Durham University

STATEMENT OF COPYRIGHT

ACKNOWLEDGEMENTS

This thesis was fully funded by the Durham Doctoral Fellowship Scheme, without which the research contained within could not have come to fruition. I am, therefore, eternally thankful to Durham for selecting my project to receive this highly sort after financial support. In addition, a veritable host of individuals have provided both help and support throughout this research project. It is now my task to give the thanks that they deserve.

Firstly, I am indebted to Matt Pope, who originally suggested the possibilities of studying handaxes as landscapes using GIS. In addition, I am very grateful for the aid and assistance given by museum curators and staff during my research trips, namely Nick Ashton, Marianne Eve, Jane Desborough and Deborah Buck at The British Museum, and Caroline McDonald at Ipswich Museum. I also extend my thanks to my friends, Al and Joe, for putting me up and keeping me fuelled with beer during my trips to London.

Members of various departments within Durham University have provided support in numerous different ways: Una Strand Viðarsdóttir and Andrew Millard for their help with statistics; Nick Rosser and Samantha Waugh for aiding with scanning the replica assemblage; Andrew Hatch for trusting me with several thousand pounds worth of equipment for my research trips; Gordon Love and Nikki Pekeur for their assistance with the scar pattern analysis and development of the computer program used. I am forever grateful to them for all of their efforts.

My appreciation goes to the fellow postgraduates for the intellectual discussion and encouragement they have provided throughout my PhD, particularly Helen Drinkall, David Clinnick, and Jenny Bradbury. In addition, Beccy Scott, Rob Dinnis, James Cole, Beccy Wragg-Sykes and Hannah Cutler deserve to be mentioned for their helpful comments and suggestions. I must also thank all of my friends and family who helped make life great and kept me sane(ish). Special mention goes to my wonderful fiancée, Elizabeth, who has put up with the stresses of not only her own thesis, but mine as well. Thank you for proofreading various drafts, spotting mistakes and generally keeping my spirits up when things went wrong. I'm looking forward to doing the same for you soon!

Many thanks go to the knappers of the replica assemblage for providing the means to test and explore the various analytical methodologies discussed within this volume. Individually, they were Karl Lee, John Lord, Phil Harding, John McNabb, Francis Wenban-Smith and Paul Pettitt.

Finally, my heartfelt gratitude goes to both my supervisors, Mark White and Peter Rowley-Conwy, for their help, comments and support. Without them this thesis would not have been achieved. I owe them both a great debt of gratitude. And, to my parents, thank you for the moral support and the brief but much needed holidays. It is finally over – you can stop asking me when I will be done now…

"If knowledge can create problems, it is not through ignorance that we can solve them" – Isaac Asimov

CHAPTER ONE
INTRODUCTION

OVERVIEW

This thesis takes its cue from the recent surge in the use of social theory to interpret Palaeolithic archaeology (e.g. Dobres 2000; Gamble 2007; Gamble & Gittins 2004; papers in Gamble & Porr 2005b; Gravina 2004). This move aims to understand the material record in terms of the social relationships that it helps forge and to force a shift in our analytical perspective. One consequence of this agenda is the promotion of the individual as the base unit in our study of the Palaeolithic, replacing the more traditional approach of using the group as our frame of reference in what has been termed the 'bottom-up' approach to analysis (Gamble & Gittins 2004). In short, this perspective holds that the way in which individuals construct their identity, maintain their relationships and establish themselves within society is fundamental to our understanding of the Palaeolithic and requires an entirely new theoretical standpoint to be formulated. To this end, it has been suggested that the actions of hominins constitute a means to comprehend the enchained relationships of individuals. It is possible that these actions can be seen within the material record, which embodies the manner in which hominin agents engaged with the world around them (Ingold 1993).

This theoretical framework is not without its critics. The shift to the analysis of the individual is suggested to provide nothing more than a new rhetorical device that is unable to move beyond 'theoretical storytelling' (Hopkinson & White 2005; Pettitt & White 2012: 161; White 2008). In addition, the study of individual hominins within Palaeolithic archaeology is potentially impossible due to the resolution of the material record (Clark 1992). While some have argued that we need not attempt to trace specific individuals *per se*, but should instead focus on the recognition of actions and agency that can be attributed to individuals (Dobres 2000; c.f. Redman 1977), others have warned that this approach risks the formation of axiomatic supra-individuals (Pettitt & White 2012: 161). In order for the agency of these supra-individuals to be validated and the socially orientated theories that rely upon them to be confirmed, we must strive towards the analysis of the *observed* individual (*ibid*.). Therefore, we should attempt to analyse and trace *actual* individuals within the material record in order to evaluate and substantiate our theories.

Some possible instances of actual individuals have been recorded within the Palaeolithic material record. Bradley and Sampson (1978) have noted several handaxes from the Lower Palaeolithic site at Caddington, Bedfordshire, that display very similar morphology, which they suggest to be indicative of the same hand. They also note *in situ* knapping scatters that demonstrate the presence of varying skill, techniques and experience. Likewise, a number of handaxes from Foxhall Road, Suffolk, are almost identical and could be the products of the same individual (Layard 1904; White & Plunkett 2004), while similar cases may be evident at Boxgrove, West Sussex (Pope *et al.* 2006; Matt Pope, pers. comm.). Other evidence of actual individuals has been recorded in the refitting cores from the sites of Pincevent and Etiolles, France (Bodu *et al.* 1990, Julien *et al.* 1992, Karlin *et al.* 1993, Leroi-Gourhan & Brézillon 1966, 1972, Pigeot 1990). However, while these are interesting isolated events, there is currently no method to trace the actions of individuals through the material record. Without such a method these unique examples are unable to aid in meaningful discourse that expands our socially orientated hypotheses beyond mere theoretical hyperbole.

RESEARCH QUESTIONS

This thesis therefore poses three research questions:

1) What are the possibilities of identifying and tracing actual *real* individual hominins in the Lower Palaeolithic archaeological record?
2) If we cannot trace individual hominins, what factors are preventing their actions from being observed and delineated?
3) Finally, whether individual hominins can or cannot be traced, what are the implications for our understanding of social theory and its application to Palaeolithic contexts?

Additionally, if individuals are visible in the archaeological record, a separate question is what were they trying to signal through their material works. To answer these questions, current theoretical approaches to the study of the Palaeolithic are explored and previous methods of analysing the individual are discussed in order to provide the background to a series of three experimental methodologies. These attempt to quantitatively identify and trace the actions of individuals within the context of formal lithic tools and the techniques used in their production, with specific reference to the Acheulean handaxes of the Lower Palaeolithic. The core of this thesis seeks to test the extent to which these proposed methodologies are able to tease out the individual from amongst the variety of other factors that also contribute to the variability of the Lower Palaeolithic record. If the results of these analyses prove positive, then a new level of investigation will be achieved that enables theories to be tested and actual *real* socially orientated relationships to be demonstrated, thus enabling more meaningful discussion of social factors within Palaeolithic research. However, if the result is in the negative, then the reasons for the individual being masked will be discussed and brought to the fore. Whatever the outcome, the conclusions of this work will have important implications for our use and understanding of current social theory and its place within Palaeolithic archaeology.

THESIS STRUCTURE AND CHAPTER OUTLINE

Following this introduction, ***Chapter Two*** provides a review of the diverse theoretical approaches that have been used to further Palaeolithic research since its advent in the 19th Century, before dissecting the avalanche of socially orientated theory that has picked up speed over the last two decades, both within the study of the Palaeolithic and the discipline of archaeology as a whole. Attention is given to the way that the individual has been examined theoretically and issues with the use of the individual as the base analytical unit are discussed. In addition, the capacities of *Homo heidelbergensis*, the hominin species responsible for the production of the British Acheulean handaxes that this thesis chooses to focus its analysis on (Hillson *et al.* 2010; Roberts *et al.* 1994; Stringer & Hublin 1999), are addressed and the implications these have for understanding their social world are expounded on. Based on this synthesis of the literature, two possible routes towards the exploration of the individual within the Palaeolithic material record are suggested.

Chapter Three takes these two suggested routes, namely the investigation of both formal tools and the technological acts used in their production, and reviews previous methodological approaches to the study of the individual that have made use of them. From these previous studies a variety of possible idiosyncratic markers that may be linked to the actions of individual hominins are extracted and used to propose three experimental methodologies, which ostensibly have the potential to trace individuals within the Palaeolithic archaeological record. These methodologies seek to analyse the individual through refitting débitage produced during handaxe manufacture, as well as the exploration of the three-dimensional morphology and scar patterning found on formal tools. The chapter concludes by describing these methodologies in detail, prior to their application to an assemblage of replica tools[1] where the knappers involved are known, in order to test their effectiveness, as well as artefacts from the Lower Palaeolithic archaeological record. The materials selected for analysis are discussed further within ***Chapter Four***. In addition to the replicas, these include assemblages of handaxes and refitting flakes from the Lower Palaeolithic sites of Boxgrove, Caddington and Foxhall Road. This chapter also provides an overview of the Acheulean and its defining tool type, the handaxe, as well as identifying potential implications for the application of the methodologies to these artefacts.

Prior to discussing the results produced by the three experimental methodologies, ***Chapter Five*** explores the more traditional metrical analysis of handaxes (e.g. Bordes 1961; Roe 1968; Wymer 1968), using the replica assemblage to do so. This discussion aims to provide a comparison between these methods and the newer, innovative techniques described in Chapter Three to show the extent to which the individual can be traced through the

---

[1] **N.B.** As the replica assemblage is discussed throughout the course of this thesis, a supplementary crib-sheet displaying both sides of these handaxes is provided for the reader's reference. This can be found inside the back cover.

shape of formal tools, which has been commonly relied upon to assess variability in the archaeological record. In addition, this chapter also posits whether a simple visual assessment of the tools, or 'eye-balling', is able to distinguish between different knappers. The effectiveness of this qualitative analysis will be subsequently contrasted with the results from the experimental methodologies in the discussion and conclusions of the thesis.

Chapters Six through ***Eight*** discuss the results from the three methodologies proposed in Chapter Three. The first of these chapters describes the findings from the analysis of the refitting material from the replica assemblage and the sites of Boxgrove and Caddington. This shows that, though some refitting sequences do cluster according to the individual that produced them, raw material variability has a much greater impact upon the progression of the knapping sequence, forcing the knapper to alter their technique. As a result, the individual's imprint appears masked. Furthermore, the investigation of the archaeological material confirms this, while indicating that the Palaeolithic refitting sequences studied are rarely of sufficient length to enable the production of accurate or meaningful results.

Chapter Seven details the investigation of the three-dimensional morphology of Acheulean handaxes. Treating the surfaces of each handaxe as a landscape, this mode of analysis focuses on the aspect and slope of the tools topography as proxies for flake scar orientation, angle of removal and degree of thinning. The results extracted from the replica assemblage clearly show that these features do not allow the individual knapper to be traced and are generally informed by the overall shape of the tools. This continues somewhat into the analysis of the archaeological assemblages and appears to be caused by differing approaches to variable raw materials, confirming what has been suggested by both White (1998a) and Ashton & McNabb (1994).

The penultimate chapter explores the analysis of flake scar patterning on the handaxes selected for study. Using an updated methodology base on Gunn's (1975, 1977) analysis of scar pattern orientation, the results indicate that tool shape is a key factor in directing the thinning approach applied, especially amongst the replica tools. However, analysis of the archaeological assemblages shows that original nodule size is also likely to be important, particularly when considering the intensity of reduction that has been applied. In addition, despite the methodologies failure to trace the individual, the possibility of a group template influencing how handaxes are manufactured is reviewed.

Chapter Nine summarises the effectiveness of the three proposed methodologies and reviews the suggestion that the individual is masked by a suite of factors, which mainly result from the variable aspects of the raw material chosen for reduction that tend to guide the knapper's decisions. Moreover, a discussion of the possibility of tracing group templates is provided. Finally, the chapter outlines the implications that the results have for the understanding and application of social theories to Palaeolithic contexts, as well as providing recommendations for future research.

SUMMARY

This thesis thus aims to provide a detailed exploration of the potential to analyse individual hominins within the Palaeolithic in response to the current advocates of social theory and the bottom-up approach to analysis of the archaeological record. While by no means a fully comprehensive account of all the possible ways that the individual can be analysed, the quantitative methods discussed indicate that individuals remain masked, thus affecting the extent to which our theoretical hypotheses are considered to be both meaningful and accurate. Finally, it is demonstrated that we perhaps do not yet fully appreciate the role of the group within Palaeolithic societies, and the study of these in further detail maybe the more appropriate route to a more informed understanding of this period of prehistory.

CHAPTER TWO
THE APPLICATION OF ARCHAEOLOGICAL THEORY TO PALAEOLITHIC CONTEXTS

INTRODUCTION

Palaeolithic archaeology, like the discipline as a whole, has evolved through a series of diverse and often polarised theoretical approaches. The latest of these has seen a move from processual to more post-processual interpretations of the Palaeolithic material record. Spanning three decades, this shift has brought about an aspiration for the more socially orientated lines of enquiry taken by those scholars who study later prehistoric periods (e.g. Barrett 1993; Chapman 2000; Hodder 1990; Pettitt 2010; Thomas 1991). As a result, many researchers now aim to reorientate the theoretical underpinnings of Palaeolithic archaeology from a "top-down" approach, focusing on groups of hominins, to one that investigates the available evidence from the "bottom-up", where the key element of the inquiry is that of the individual (Gamble 1999; Gamble & Gittins 2004). As already mentioned in the introductory chapter, the aim of this thesis is to address problems that have been observed in these current theoretical arguments and how they have been applied to Palaeolithic contexts. However, before getting to grips with these issues, it is important to provide the background to the various theoretical upheavals that have impacted upon Palaeolithic and prehistoric archaeology.

The current chapter will begin by providing a brief discussion of the various theoretical insights that have been used to make sense of the remote periods of time that are the Palaeolithic archaeologist's domain. While this cannot be compared to a comprehensive account, such as those produced by Trigger (2006) or Daniel (1950, 1981; Daniel & Renfrew 1988), it will serve to highlight changes in theoretical perspectives that have led to the current sociological approaches to archaeology as a whole. After outlining the evolution of archaeological thought, recent post-processual theories will be discussed in order to address perceived problems with their application to Palaeolithic contexts, most notably the use of the individual as the primary analytical unit of archaeological discussion. This will provide the necessary backdrop for the main body of this thesis, which aims to test the sustainability of the "bottom-up" approach.

PAST APPROACHES TO THE PALAEOLITHIC

Antiquarianism and Culture History

Although the subject was first given its name by Lubbock in 1865 (Trigger 2006: 94), the beginnings of Palaeolithic archaeology can be traced back as far as 1679, when John Conyers found the famous Gray's Inn Lane handaxe, in association with the bones of what is now presumed to be a mammoth (Daniel 1950: 26; Daniel & Renfrew 1988: 31; Roe 1981: 19; Wymer 1968: 289), although society at the time lacked any analytical framework with which to make sense of this artefact. John Frere's recovery of flint artefacts from the depth of some twelve feet at Hoxne in 1797, which he attributed to "weapons of war" from a "very remote period indeed" (Daniel & Renfrew 1988; Frere 1800: 32), passed similarly unregarded (Roe 1981: 19), even through his paper had included a stratigraphic description of the find and section of the deposit where it had been found (Schnapp 1999: 285).

It was not until 1859, when John Evans and Joseph Prestwich confirmed Boucher de Perthes finds from Amiens that prehistoric archaeology truly came into being and the finds of both Conyers and Frere were accepted (Daniel 1950: 28; Evans 1860; Gamble 2008: see also Lamdin-Whymark 2009 and Pope & Roberts 2009 for detailed accounts). Around the same time, Falconer and Pengelly had made significant finds at Brixham, which also suggested the extended antiquity of such stone tools (Daniel 1950: 58; Walker 2009: 30). The timing of these discoveries was fortunate in that they occurred alongside the Darwinian revolution and the drive by geologists to refute the 'Diluvial Theory' in favour of 'Fluvial' and 'Glacial' theories that provided a much longer timescale (Gowlett 2009: 21-2; Roe 1981: 21). This marked the beginning of what has been termed the *heroic age* of Palaeolithic studies (Gamble 2009). This period saw the earliest scholars begin to plumb the chronological depth of prehistory and began the study of variation in lithic technology (*ibid*.), which has been continued throughout Palaeolithic research (e.g. Roe 1968).

The *heroic age* produced innumerable collectors of antiquities, who were actively encouraged to acquire specimens of stone tools (Evans 1860: 307; Roe 1981: 23). Although many of these did so without noting the stratigraphic context and locality of their finds (Roe 1981: 24), there were others who were much more scrupulous in their endeavours, such as W.G. Smith, whose publication *Man the Primeval Savage* is still an important document and whose finds from Caddington have become part of the focus of this thesis. However, after 1860, most of the advances made in Palaeolithic archaeology took place in France, which provided superior evidence for the antiquity of man than was available in England at the time (Trigger 2006: 95). Chief among the French scholars were Edouard Lartet, who realised the Palaeolithic was a series of phases that were distinguished by their material culture, and Gabriel de Mortillet, who continued Lartet's work in subdividing the period (Sackett 1981; Trigger 2006: 95). However, both were heavily influenced by geology and palaeontology (Sackett 1981) and adapted the views of evolutionary relationships seen in fossils to the stone tools that had been discovered (Gamble 1986: 10). Although they introduced much of the familiar terminology that we use today, such as the Magdalenian and Mousterian, these represented temporal phases within a unilinear evolution of what they considered to be a single cultural tradition (Sackett 1981: 86). Such an evolutionary view also led to the notion that the earliest tools would be "so crude that they could not be distinguished from naturally broken rocks" (Trigger 2006: 98), resulting in large numbers of naturally flaked 'eoliths' being accredited to, what Mortillet termed, the 'Thenaisian and Puycournian Epochs' (O'Conner 2007; Roe 1981; Trigger 2006). Although eventually discredited (see Grayson 1984) and shown to be the result of pressure produced by soil movements (Warren 1923), the controversy over the credibility of such artefacts led to intensive experimental work into the nature of lithic technology (Trigger 2006: 98) that still continues today (Gamble 2009).

The beginnings of Palaeolithic research highlight the scientific approach that was and, to some extent, still is part of the study of this period. It used stratigraphic observations to explore regional sequences (Gamble 1986: 9) and was held in high esteem for its ties to the natural sciences and its ability to prove the antiquity of man (Trigger 2006: 101). However, its focus on artefacts and their classification produced a limited view of past populations, especially when compared to contemporary Scandinavian prehistoric archaeology (*ibid*.: 101). This appeared to continue into the early 20th Century and the introduction of *straight archaeology* in France, with Sackett (1981) describing those involved as "preoccup[ied]…with the typology of artefacts and the structure of the sites from which they derive". Therefore, prior to the 1950s, research focused on devising a sequence for the succession of Palaeolithic cultures (Daniel 1950: 231), progressing from unilinear evolution approach to one that produced a phylogenetic account of stone tools that depicted regional variation in stone tool evolution, and led to Bordes' (1981 in Gamble 1986) division of the Mousterian into five groups, which he regarded as the product of five Neanderthal tribes. Many tenets of this period of archaeological thought, such as the reliance on typology to group artefacts into specific categories and the tendency to attribute these to chronological periods and cultural divisions, as well as the using changes in material culture as proxies for changes and developments in cognitive and cultural evolution, have carried over into our modern interpretations, though often modified, thus showing that we still owe much to Palaeolithic archaeology's birth over 150 years ago.

The New Archaeology

As early as 1950, archaeologists began to explore the possibilities of statistical and scientific analysis of artefacts (Roe 1981: 29), which heralded the approach of the New archaeology. The beginning of this processual approach can be seen in the early writing of Binford (1962, 1968) and took the form of "a rebellion against what were considered sterile and non-productive endeavours" (Binford 1977: 9). It held a view of culture that was completely different to that of culture history (Gamble 1986: 13) and advocated studying the effects of environmental and demographic factors as causes of culture change (Gamble 1986; Johnson 1999; Sabloff 2005; Trigger 2006). Resulting from an air of dissatisfaction with the attempts to reconstruct the past without actually explaining it (Daniel & Renfrew 1988: 162) as well as a desire to break away from the *normative* ideas produced by Childe (Johnson 1999), amongst others, those involved in advancing the processual archaeology aimed to make the discipline more scientific and bring it closer in line with anthropological thought (Daniel & Renfrew 1988; Johnson 1999; Sabloff 2005). This aspiration for a more rigorous analysis of the archaeological record was supported by numerous advances in physical, chemical and botanical techniques (Clarke 1973: 10). While these new methods aspired to a more holistic examination of culture, which was now viewed as a system to be understood (Johnson 1999: 22), it concentrated more upon subsistence, trade and social organisation than it did on ideology or religion (Sabloff 2005; Trigger 2006). Therefore, most analyses dealt with fields that fell within the lower rungs of Hawkes' (1954) ladder of inference (Trigger 2006: 327).

It is true, as Johnson (1999) has argued, that the processual approach had a great impact upon prehistoric archaeology and especially the Palaeolithic, but by the 1970s, many had begun to see problems emerge (Trigger 2006: 328). Such problems included the raising of unrealistic expectations, the lack of detailed explanatory modes to support the increasingly rigorous and scientific analysis, and the absence of ideology and religion from the "holistic" systems approach, which instead centred on relationships formed between technology, environment and economic factors (Sabloff 2005). This was seen even amongst Palaeolithic archaeologists, with some noting that disturbed sites offered little to no interpretive value (e.g. Roe 1981). In addition, the imagery created from archaeological interpretations tended to support a natural history approach, focusing on the relationships forged between the multiplicities of data gathered from the Palaeolithic record, something that still continues to an extent today (Gamble 1999). However, efforts were made to address such issues, the most important of which is, arguably, the introduction of middle-range theory (Binford 1977), a concept that has been applied to a wide variety of Palaeolithic research (Levent Atici 2006).

Binford noted that in order to infer the dynamics of past societies using static archaeological data one must assume 'middle-range' links between the two – i.e. that the processes observable today provide a common bridge between it and the past. This then allows generalisations to be made about the past in an explicit sense (Johnson 1999: 49-50). Binford used ethnography to provide such links, as well as experimentation to recreate the skills used in the production of material culture (Binford 1983; Trigger 2006: 22). To work, middle-range theory was required to satisfy two conditions – that it was kept separate from the general theories that were being tested, and that it must work under the assumption that conditions in the past were very much like those in the present (Johnson 1999: 54-5). This poses certain problems, not least for the study of the Palaeolithic, where fluctuating climatic conditions, extinct hominins and a wide array of species that have now been wiped out make for a very different environment from any we could study today. Also, many archaeologists now suggest that social factors common to the societies they themselves are part of limit the questions they can ask of the archaeological record, which constrains the answers that we are willing to credit with the highest degree of confidence (Trigger 2006: 1). Yet, even though it has been criticised for its narrow focus on site formation processes (see Raab & Goodyear 1984), middle range investigations have continued in Palaeolithic archaeology (Bar-Yosef 2001; Binford 2001; Levent Atici 2006; Thery-Parisot 2002).

While such middle-range theories provided a clearer image of what is and can be understood about the Palaeolithic, the interpretations that resulted were not explained in terms of the social factors that would have been major driving forces within Palaeolithic society (Gamble 1999). The overall agenda of the processual ideology was a move away from the previous culture historical approach, eschewing social explanations in favour of natural, or systemic interpretations. As a result, Palaeolithic archaeologists focussed on dualities between ancient and modern hominins, environment and culture, and foraging versus agriculture (*ibid.*). In addition, the processual focus on scientific analysis to form objective interpretations contained inherent issues, not least the fact that we will always have problems in testing propositions about the past and trying to understand human behaviour, which is not insensate in the way that chemicals are (Johnson 1999: 42-43). Therefore, interpretations of the Palaeolithic were limited, though archaeologists focused on what they considered to be truly important, namely understanding the development of the processes behind civilisation and what makes use human (Gamble 1999: 5).

SOCIAL ARCHAEOLOGY AND THE INDIVIDUAL

Despite attempts to remedy the issues within processual archaeology, increasing dissatisfaction with this suite of approaches ultimately propagated a paradigm shift, which saw the emergence of new socially orientated methodologies that, rather presumptuously, labelled themselves 'post-processual'. Accusing the new archaeology of putting "all its eggs in the basket of neutral methods" (Hodder 1992: 2), it began to show that patterns in the archaeological record could be interpreted in various different ways, with no way to test between such possibilities (for example in Hodder & Orton 1976). Hodder was at the forefront of this movement and realised that the only way to unravel archaeological data was to investigate the relationships between pattern and process in the present (Johnson 1999: 99). However, Hodder's enthnoarchaeological work showed that the patterns that we see are directly related to the individuals involved in them (Hodder 1982), which has since led to the study of agency, with many elements borrowed from structuration theory (Giddens 1984). This produced a shift from the study of the material record using highly scientific techniques, to one that provided a more socially orientated approach, causing numerous conflicts throughout the archaeological community (Rowley-Conwy 2001), echoing the disagreements voiced over the earlier new archaeology (e.g. Hawkes 1968).

This social archaeology built upon the processual call for more socially based studies (Friedman & Rowlands 1977; Redman *et al.* 1978; Renfrew 1973; Renfrew & Shennan 1982), resulting in a new rash of social theories (e.g. Barrett 1988, 1993; Dobres 2000; Dobres & Robb 2000; Hodder 1990; Shanks & Tilley 1987; Thomas 1991). However, as Gamble (1999: 5) notes, the Palaeolithic seems to have been divided from the rest of archaeology, due to the fact that its material record is more suited to natural and systemic interpretations than social ones. Therefore, Palaeolithic archaeologists have continued to focus on evolutionary and adaptive explanations for variability amongst artefacts (Gamble & Gittins 2004), stating that the study of social agency and behaviour are beyond the resolution of the available data (Clark 1992; Wobst 2000). As a result, our theories have been reliant upon the use of the hominin group as the base unit of analysis (Clark 1992; Gamble 1998a; Gamble & Gittins 2004; Gamble & Porr 2005b).

Towards a 'social' Palaeolithic

Over the past two decades, the study of agency and individual behaviour, which this thesis explicitly focuses on, have slowly made their way into interpretations of the Palaeolithic. Initially, this was confined to discussions of the Upper Palaeolithic (e.g. Dobres 2000; Grimm 2000; Mithen 1991, 1993; Pigeot 1990; Sinclair 2000), perhaps due to the suite of behavioural changes that are believed to occur at this time, such as: fully modern language (Lieberman 1989, 1992, 2007), a brain capable of modern thought (Dunbar 2003; Mithen 1996b) and the appearance of external symbolic storage systems (Wadley 2001). As a consequence, Lower and Middle Palaeolithic studies have been disconnected from these social approaches, leading to what Gamble (1999) has termed a divided archaeology.

In an attempt to change this, Gamble (1998a, b, 1999, 2004, 2007; Gamble & Gittins 2004; Gamble & Porr 2005a) began to stress that Palaeolithic archaeologists needed to address the social effects of individual decision making and adopt a "bottom-up" approach to analyses. This has led to a number of recent papers that turn away from previous approaches to the study of the Palaeolithic in favour of more socially orientated perspectives designed to discuss individual hominins and the affects of agency on the material record (e.g. papers in Gamble & Porr 2005b; Gravina 2004). However, while it is agreed that the application of social theory will be of great benefit, there is still the lack of a defined methodological framework that allows archaeologists to interpret the social aspect of material culture beyond what has been called naïve reconstructionism (Hopkinson & White 2005: 27).

The processual individual?

Although the idea of social archaeology has only recently entered into discussions of Palaeolithic archaeology, the concept of the individual being at the centre of any discussion is not necessarily a new theoretical position. The individual had made its way into Bradley and Sampson's (1986) experimental analysis of Acheulean handaxes, where they noted that artefact variability begins with the knapper themselves. Earlier still, Gunn (1975, 1977) proposed a methodology through which individuals could be traced via variation in final tool form. Yet these studies were caught up in attempts to explain variation in terms of adaptation, evolution and social systems, the mainstays of the processual archaeology, rather than using them to study social relationships (Barrett 1988; Dunnell 1978; Jones 1997). Similarly, Binford (1962, 1965) saw variation, in stylistic terms, as a signature of ethnic difference, which was separate to the functional qualities of the artefact that were intended to render past processes in sensible terms (Dunnell 1978).

The dichotomy between function and style that this introduced was critiqued by Sackett (1977, 1982, 1985), who suggested that style itself was inherent to choices made, while the functional product remained static. Therefore, style and function could not be separate, but went hand in hand. Sackett also suggested that what he termed *isochrestic variation* was derived from and prescribed by culture; thus positing that a correlation with ethnicity could be formed (Jones 1997). However, this view of style has been questioned by Lemmonier (1992: 89-91), who has stated that this "does not tell us anything about the…means for communicating social information". Instead, the only function that can be ascribed to *isochrestic style* is its ability to observe the possible adaptive advantages of particular shapes (*ibid*.: 90). Jones (1997) was also critical, suggesting that this explanation of variation is akin to a congealed representation of Bourdieu's (1990) *habitus* that, under these terms, renders the relationship between and individual's identity and their material culture inaccessible.

More recent research aims to move beyond these approaches by exploring the decisions and motivations behind artefact manufacture (e.g. Schlanger 1994, 1996). Combined with studies of social agency, they attempt to draw back Gamble's (1999) interpretive curtain and form an approach to material culture studies that aims to unlock the social information that artefacts are held to contain. This analysis circumvents the Westernised view of technology, where material culture's social impact is something that occurs below the conscious level (Pfaffenberger 1988), by linking technology with the social constructs that materialise through it use. Current approaches, therefore, attempt to dissect the social relationships that are embedded within material culture.

Agency and the individual

The concept of social agency has now become central to many studies of material culture due to the opinion that artefact variation can be interpreted in multiple ways (Lemonnier 1992) and the realisation that people negotiated their world through both social and material interaction (Dobres & Robb 2000). Technology is, therefore, seen as a total social fact (Mauss 1950; Schlanger 1990); the resultant product of both human choices and social processes (Pfaffenberger 1988: 239). Individuals actively fashion their worlds through the use of technology (Winner 1986: 14-15) and, at the same time, technology also constructs the people themselves via the social relationships and experiences that form through its use (Dobres 2000; Dobres & Robb 2000; Gosden 1999; Pfaffenberger 1988).

Once again, such ideas are not exactly novel. Despite being focused on the study of systems, Childe (1956: 1) had suggested that artefacts embodied expressions of human thoughts and ideas. Binford (1962) also stressed the importance of links between individual social processes and material culture, while Redman (1977) pointed out that using the smallest analytical unit available to us would lead to an understanding of how individuals contributed to social change. This again reinforces the fact that our current theories cannot escape from those of the past, something that will be returned to later in this chapter. However, although these studies acknowledged the individual, the focus remained on the study of systems that left the role of agency and the contributions of individual agents locked in Dobres' 'black box' (Dobres 2000; Dobres & Robb 2000).

Recent studies have brought our focus back to these agents and have begun to address how their sociality was formed from individual events (Hodder 2000). By investigating such events, for example the refitting of flint débitage (e.g. Grimm 2000; Pigeot 1990; Schlanger 1996), reconstructing evidence of an individual's agency in the Palaeolithic becomes a distinct possibility. However, isolating such events prevents our understanding of how individuals involved themselves in their surrounding social structures (Hodder 2000). Therefore, in these instances, we can demonstrate one individual's agency, but we cannot extrapolate from this the agency of other individuals, nor the social milieu in which they existed (Foulds 2010: 7). As Chase (2006: 2) emphasises, it is not enough to understand the ambitions and ideas of individuals when searching for the answers to innovations and change in material culture. We must aim to study the interactions of those involved in cultural creations and changes.

There are other problems with the analysis of the individual. The notion of the individual is a concept that has been criticised for being heavily influenced by Western thought. Thomas (2004) has emphasised that our focus should be the study of how relationships sustained people in the past, rather than relying on the presumption that the individual is the core of all social matters. This is complicated further when one accepts that fact that persons can perceive themselves not as individuals, but as dividuals that make up a greater whole (see Busby 1997). Chapman (2000; Chapman & Gaydarska 2006) has taken this concept and used it in the creation of a methodology that interprets the fragmentation and accumulation of objects as links between people and their material culture. From this perspective, the individual person becomes dividual; constructed from social relationships, as opposed to their own experiences (Knapp & van Dommelen 2008: 16). This then means that we cannot rely on our own assumptions about how prehistoric people, and especially archaic hominins, viewed themselves in the past.

If we accept that we cannot translate the archaeological record based on our own concepts of individualism then, as Moore (2000) states, we can no longer equate the agency producing actor with the individual. Therefore, we can assume that specific persons created, manipulated and discarded the material culture that we excavate, yet we cannot fully understand how these agents conceived of themselves (Knapp & van Dommelen 2008: 17). This is a significant problem when considering how the hominins that we wish to study actually conceived of the world around them. It appears that we still need to obtain a better resolution of social actors, who are "intimately implicated in maintaining and transforming social structures, values and practices" (*ibid*.). As a result, I would argue that by tracing the actions of single specific entities in the archaeological record we can begin to reconstruct the relationships between actors, material culture and their social framework, which should ultimately be the goal of more socially informed studies.

However, following the insistence of Redman (1977), it has been argued that the study of agency should not devolve into the search to traces of specific actors in the material record (Dobres 2000; Dobres & Robb 2000; Sassaman 2000). Instead, our focus should be on actions that are clearly represented in the physical evidence that we excavate (Sinclair 2000), which can be seen as created through the conscious and unconscious decisions that influence social bonds and form the *habitus* of daily life (Bourdieu 1990; Giddens 1979). However, this approach does not allow for such social bonds to be explored and disconnects the action from the individual actor, thus removing the person responsible for such actions from the social relations we wish to study, and of which they are an integral part. If agency is used in the creation of an actor's identity, which in turn is constructed from that actor's experiences, constrained by the larger social whole and expressed through their material culture (Bourdieu 1990; Giddens 1979), does this not mean that they should be the focus of our study as opposed to simply the actions they make? If we understand the problem in this way, the actor becomes a "world within the world" (Bourdieu 1990, 56); a social construct that is aligned with the greater 'society', but formed from its own specific relationships and experiences (contra Knapp & van Dommelen 2008). They become contained within society, but are also separate from it at the same time. Therefore, the study of the single agent, the action that they produce and how this relates to the actions performed by other agents within the social network, as opposed to a study of action in general, can be said to be useful, as it would allow for a greater understanding of social relationships and the perception of identity.

APPROACHES TO THE PALAEOLITHIC INDIVIDUAL

As mentioned above, studies that concern themselves with the Palaeolithic individual have a long pedigree (see Bradley & Sampson 1986; Gunn 1975, 1977). Here it must be noted that the term individual is used to refer to a single social actor, as opposed to the Western concept of a bounded self. While these earlier studies discussed individuals, they can also be interpreted as referring to single agents, rather than beings that conceived of themselves in any specific way. However, as we have seen, these studies were limited in their focus and studies of social concerns have been a more recent development in Palaeolithic research.

Mithen (1990, 1991) was one of the earliest to pursue the interactions of individuals in Palaeolithic contexts. His focus was on the 'generic' individual and he was more concerned about the *individual decisions* that could be seen in the material record, rather than the decisions *of* individuals (Bahn 1991). Concepts such as memory, information and planning were taken as implicit markers of cognitive action and, therefore, individuals (Mithen 1993: 395), where the individual is understood to be the smallest unit with the group. Mithen (*ibid*.) agreed with Clark (1992) that tracing specific individuals was outside the scope of the available material evidence, except in rare idiosyncratic events, such as cave paintings and refitting tools.

Later studies have tried to explore the individual in greater depth by analysing these idiosyncratic episodes. Schlanger (1990) noted that the techniques used in tool manufacture are tied to social life, but such ties are often intangible, especially when we try to view them through material evidence. However, he went on to demonstrate that the enactment of any technique expresses the social aspect of that technique. Each gesture that is used in the process of performing a technique can be correlated with the actor's choices, assessments and decisions in the generation of knowledge, which is embodied in the resultant tool (Schlanger 1994). These concepts were used to show the interplay between mental and material in the production of Levallois flakes (Schlanger 1996), indicating that the process of flint reduction involved a "fluid articulation of knowledge…rather than [being] hard-wired and thoughtless" (Gravina 2004). However, Schlanger's analysis did not link such processes to the social conditions that surround how actors negotiate their worlds, nor did he demonstrate how such techniques were developed and passed on (Dobres 2000).

The study of apprenticeship has made some progress towards the incorporation of the social actor into the analysis of Palaeolithic technology. Pigeot's (1990) study of refitting material at the Magdalenian site of Etiolles, France, is one such study, which acknowledges that art and burial are areas in which the individual is clearly expressed, but that these events are merely distorted reflections of society. On the other hand, lithic tools and their use are habitual elements of all Palaeolithic societies, and throughout the knapping process the expression of the knapper is inscribed on the tool with each percussive action. Through the analysis of these actions, the aims of the individual involved can be brought to light and differences in knapping skill can be demonstrated, something that has continued to be illustrated at Palaeolithic sites (e.g. Grimm 2000; Stapert 2007) and suggests that both expert and novice knappers can be identified from material remains. This has important implications, as processes of learning and practice not only begin to engender actors within the past, but also bring our understanding of technical knowledge back to a habitual or heuristic sphere, which enables our study of agency through technique to occur almost seamlessly (Sinclair 2000). However, the main problem with these studies is the actual loss of the individual within discussions that centre upon the group. Therefore, though the individual is analysed, it is the possibilities for understanding the group that result.

Gamble has attempted to move beyond these issues. He notes that social theory does not sit well with scientific analysis (Gamble 1999: 8), as is the case with Giddens' (1984) structuration theory, which seems to almost reject a scientific approach. This has carried across to archaeological thought, which points out that a narrow scientific view of the data does not account for human action (Thomas 1991). While Gamble (2004) acknowledges that sociality resides in the objects that form hominin cultures, and that these should be the focus of our inquiries into socially extended interactions, he has also stated that we should not break from past traditions (Gamble 1999). Arguing that Palaeolithic archaeologists do not yet have a sufficient methodology for the study of artefacts in terms of the social and individual (Gamble 2004: 20), he has proposed the use of a narrative approach (see Gamble 1999) and turned to Chapman's (2000) fragmentation hypothesis.

However, initial attempts to use these concepts, such as in the analysis of carcass butchery at Salzgitter-Lebenstedt (Gamble & Gaudzinski 2005), have done little more than talk of individuals whilst discussing the group in general.

Gamble's latest attempts continue the theme that accumulation and enchainment were fundamental to the formulation of identity in the Palaeolithic (Gamble 2007). Although it has been stated that individuals gain their identity through the use of language (Shanks & Tilley 1987: 65), Gamble acknowledges the fact that the concept of agency in the creation of social ties formed through material culture means that the Palaeolithic is the starting point for material interference between individual actors and the world around them (Wobst 2000). Therefore, hominins have always been concerned with the construction of identity, even prior to the acquisition of language (Gamble 2007: 166). However, there are a number of issues with Gamble's approach to the study of the individual and their identity.

While not contesting the idea that material culture has an implicit role in the creation of identity, Gamble's use of material culture as a proxy for the human body, through which relationships are formed, is flawed. It can easily be accepted that groups of objects can provide links to the chains of relationships of which they were a part. But while this approach appears to be moving our interpretive focus from the hominin group, we are not replacing it with individual, but with groups of accumulated items. Therefore, we are simply switching our analysis from one analytical group to another, rather than achieving the study of the individual that we apparently desire.

The notion of the childscape is also problematic. Although this approach recognised the fact that childhood is the time in which much of a person's identity is formed (Shanks & Tilley 1987: 64-5), the childscape is, as Gamble (2007: 229) points out, hidden from us. He suggests, however, that the childscape can be thought of as continually created and reproduced through the experiences formed from material culture. Therefore, the evidence for the childscape is visible in the accumulation, fragmentation and consumption of artefacts that enchained relations throughout the child's world (*ibid*.: Chapter 8). However, this proposition is more to do with a way of thinking about the material evidence, rather than a proposition of a methodology that explicitly allows us to unravel social relationships that exist within artefacts. Therefore, Gamble appears to have turned away from his original statement and broken with previous techniques, leaving the individual he wishes to study lost in metaphor and rhetoric that is designed to promote thinking and experience (White 2008), more than analysis and understanding.

While fragmentation, accumulation and enchainment are important elements that should not be ignored in Palaeolithic research, the current lack of a methodology that allows the individual to be isolated, coupled with the broad tool cultures that span large geographical and temporal regions, limits its value and use. Where it can be shown to be most useful is in the analysis of high-resolution events, such as inter-site lithic refitting. However, demonstrating that such refits can be correlated to enchained relationships produced through the exchange of flint artefacts is much more difficult. In such situations, a single individual or group of individuals may have produced these tools, removing the theory of inter-site relationships between different actors, but allowing us to consider hominin movement patterns through localised areas. On the other hand, tools may originate from different temporal periods, meaning that we cannot rule out whether knapping occurred in one specific instance, or was extended over a longer period of time. Indeed, we cannot even rule out the possibility of raw materials being discarded by one individual and then being picked up and rejuvenated by another, something that is complicated even further when one takes into account that vast periods of time that may have occurred between these events! In order to prise apart this tangle of possibilities, it would be prudent to focus on tracing the actions of individuals in order to follow the spread of the material culture that they create before we are able to discuss the relations that such dispersal produces.

INDIVIDUALS AND LOWER PALAEOLITHIC SOCIAL LIFE

Given that the focus of this thesis is the study of the Lower Palaeolithic, it is important to highlight what aspects material culture can reveal about both hominin individuals and their social lives. Here a brief overview is provided focusing on research into: the global patterning of the Acheulean; hominin behaviour, sociality and Lower Palaeolithic social life; and the context of the Acheulean in specific reference to Britain, the region in which the sites discussed in this thesis originate.

The Acheulean in global context

Prior to the last decade of research into the Lower Palaeolithic, the presence of hominins within the European continent was thought to have occurred no earlier than ~600 ka BP (c.f. Roebroeks 2001, 2006; Roebroeks & van Kolfschoten 1994, 1995a), with the first appearances of the Acheulean and the tool form that is to be central to this thesis – the handaxe. However, there is increasing evidence that hominins had spread out of Africa by ~2 ma BP (Dennell 2004; Dennell *et al.* 1988) and into parts of Europe by ~1.2 ma BP at the latest, with some suggesting even earlier dates (Pettitt & White 2012). This period of occupation is both technologically different, consisting primarily of Mode 1 (Clark 1977) core and flake industries, and limited in its available evidence (Roebroeks 2006), presenting a picture of short-lived occupations (Dennell 2003). When contrasted with the later Acheulean, it may appear that there were two successive waves of colonisation, though in reality these are more likely to be formed from a series of dispersals and localised extinction events on a continental scale (Carbonell *et al.* 1999, Carbonell *et al.* 2010, Dennell *et al.* 2011, Moncel 2010).

The later phase of colonisation, represented by the spread of the Acheulean, began with an early spread out of the African continent, with its earliest occurrence currently recorded in East Africa ~1.6-1.4 ma BP (Asfaw *et al.* 1992). Early evidence can be seen at 'Ubeidiya at around 1.4-1.2 ma BP, though consistent production of handaxes is limited until much later – c.780 ka BP, as displayed by the site of Gesher Benot Ya'aqov (Bar-Yosef 1998; Goren-Inbar 1992). This is also around the time that the earliest examples of Acheulean industries have been dated to in Europe, with Caune de l'Arago, France securely dated to ~700-600 ka BP (Barsky & de Lumely 2010). This may suggest that the Acheulean industry was not developed *in situ* within European locales, but was instead introduced from other regions (*ibid.*). By the end of MIS 15, the Acheulean is readily found throughout Europe (Roebroeks & van Kolfschoten 1995b) and its use continues until the Middle Palaeolithic, although Central Europe displays an absence of handaxes and continued use of core and flake based industries until this latter period (McBurney 1950; Moncel 2010; White 2000).

At its height, therefore, the Acheulean had a very broad geographical spread, stretching from South Africa to Northern Europe, and from the Iberian Peninsula as far as India and Nepal (Goren-Inbar & Sharon 2006; Schick & Toth 1993; Sharon 2007). However, despite its large distribution and the extensive temporal period during which it was used, the Acheulean has been described as both 'monotonous' and 'stagnant' due to the its limited technological diversity (Isaac 1972, 1976). Nowell and White (2010) have suggested that the remarkable stability in tool form seen within the Acheulean may be the result of group size constraints, based on the work of Shennan (2001). Though variation does take place, this appears to be modification around a central theme, and major innovations may not have taken hold due to the limited size of hominin groups in the Middle Pleistocene.

The degree of standardisation versus variability has received a great deal of attention within the literature (for example Ashton & McNabb 1994; Crompton & Gowlett 1993; Gowlett 1998; Isaac 1977; McPherron 2000, 2006; White 1998a; Wynn 1995; Wynn 2002; Wynn & Tierson 1990). Part of this debate concerns whether strong patterns of variability around a modal form, seen across large spatial and temporal arenas (Gowlett 1984, 1996; Isaac 1972), may or may not be indicative of variable 'traditions' of handaxe manufacture, especially given the assumption that hominins inherited the necessary skills to accomplish tasks such as handaxe manufacture through the process of social transmission (e.g. Mithen 1994; Mithen 1996a, 1999; Shennan & Steele 1999; Stout 2005). Some argue that the uniformity of the Acheulean and the apparent conformity to a perceived 'mental template' suggests a strong tradition (Mithen 1996a, 1999). However, there is still the argument of whether this was a tradition of basic homogeneity, or if distinctive patterning in handaxe shape from different regions actually provides evidence of regional 'traditions' (Wynn & Tierson 1990). McNabb *et al*. (2004), on the other hand, have argued that there is very limited of social transmission of a group tradition based on their analysis of data from sites in South Africa. However, this study is much more localised in nature, which may lead to the conclusion that any notion of 'tradition' that was held in the Palaeolithic was rather weak (Lycett & Gowlett 2008). However, Mithen's (1994) study of the Acheulean and Clactonian in Britain suggests strong tradition in the former and much weaker tradition in the latter.

Lycett and Gowlett (2008) have discussed this disparity in the academic community over whether traditions of handaxe manufacture truly exist in detail. They note that there *is* broad geographical variation present within the Acheulean that suggests the presence of a serial founder effect, supporting the hypothesis for introduction of the Acheulean to areas such as India and Europe from external sources (Lycett 2009), though this analysis was based on a relatively small sample (n=255, compared to the thousands of handaxes recovered from the record). In an attempt to reconcile the arguments between broad scale variation and the apparent absence of clear distinctions at the intra-regional level (e.g. McNabb *et al.* 2004), they suggest two possible modes of cultural transmission that were used during the Acheulean; vertical, or parent-to-child, and many-to-one, or concerted (after Cavalli-Sforza & Feldman 1981). It is the latter of these that they favour, given that a many-to-one mode is a more general manner of social transmission that can be equated to extremely low levels of innovation and slow cultural evolution (Lycett & Gowlett 2008: 308) and conclude that the Acheulean can be seen as a tradition in the sense that this industry was formed from the transmission of an essential idea by knappers over an extended temporal period. However, this also emphasises that the act of tool production was an inherently social one, indicating that the Acheulean tool set was an integral part of the social lives of *Homo erectus* and *heidelbergensis* and can be considered to stand at the centre of hominin sociality (Porr 2000).

The British Acheulean occupation and potential handaxe patterning

As mentioned above, Mithen (1994) has argued for strong evidence of strong tradition within the British Acheulean, linking differences in learned behaviour to environmental factors. White (1998a, b) has also noticed the presence of certain characteristics within handaxe manufacture that could not be explained by extra-somatic factors and may be linked to cultural variations, including occurrences of tranchet removals, presence of burin like removals at Whitlingham, Norfolk, and the prevalence of twisted ovates amongst some assemblages. Some of these occurrences may be due to the settlement history of Britain within the Pleistocene, which appears to be formed from a series of colonisation and extirpation events.

Early colonisation of Britain, prior to the first appearance of the Acheulean in Britain, occurs between MIS 25-17, is evidenced from sites such as Happisburgh and Pakefield (Ashton & Lewis 2012; Hosfield 2011). While Pakefield displays conditions similar to the Mediterranean (Candy *et al.* 2006; Parfitt *et al.* 2005), the occupation at Happisburgh appears to have occurred in a boreal zone, demanding novel adaptive skills to accommodate environmental pressures (Parfitt *et al.* 2010), suggesting that rudimentary clothing (White 2006b), fire (Gowlett 2006a) and shelter (Chu 2009) may have occurred as early as 1 ma BP, though there is currently no evidence for these technologies being present at this time.

Following this earliest occupation, human presence has been detected in the interglacial periods represented by MIS 13, 11 and 9, as well as the beginning and end of MIS 12 and 10 (Pettitt & White 2012). It is evident that this occupation was not continuous, but rather an ebb and flow of populations responding to the changing landscape. A primary factor influencing the ability of early hominins to colonise Britain during these periods was the presence/absence of a land bridge connecting the island to northwest Europe (Ashton & Lewis 2002; White & Schreve 2000). White and Schreve (2000) proposed a model of human colonisation based on this and environmental factors relating to the climatic oscillations of the marine isotope stages, which has been expanded on by Pettitt and White (2012). This proposes that colonisation of Britain as a peninsula of Europe took place during the cooling periods prior to a glacial. This was followed by abandonment and localised extinctions due to increasingly inhospitable climates and reduced resources as glacial conditions worsened. As the climate ameliorated following these glacial periods, colonisation would have been re-established, though rising sea levels would then have resulted in hominins becoming isolated from mainland Europe. White and Pettitt (*ibid*.: 114) have also postulated that stadial sub stages may have reconnected Britain with the mainland, though it is unknown whether hominins used these opportunities to abandon isolated Britain, or remained. Such periods would have also allowed the introduction of further animals and people to Britain, and perhaps even new technologies.

Therefore, given that Britain is a 'sink' region, characteristics linked to potential cultural variation, such as those discussed above, may have been introduced by colonising groups in addition to spread through inter-group networks and localised operational areas (Pettitt & White 2012; White & Pettitt 2011). A primary example is found in the twisted ovate phenomenon (White 1998b), which can be attributed chronologically to MIS 11/10, suggesting that there is some pattern in temporal clustering of these artefacts, despite limited evidence of spatial clustering (White & Schreve 2000). It is possible that this technique was common amongst early colonisers and insularity helped sustain this manufacturing technique, though earlier assemblages from Swanscombe and Hoxne where twisted forms are rare argues against this. It is also possible that the twisted form was an under used variant, which then proliferated with the isolation of Britain from the continental mainland.

White also sees further chronological patterning that may be due to the nature in which Britain was colonised (Pettitt & White 2012; White pers. comm.). Using Roe's (1968) handaxes groups, which initially display no evidence of patterning based on broad differences between pointed and ovate forms, finer scale variation within the sub-groups can be linked to chronological patterns based on date ranges from sites with recent age correlations from a variety of methods, including biostratigraphic, lithostratigraphic and absolute dating. If White is correct and this chronological patterning is real, then this may be a step towards an explanation as to why strong traditions may be seen within intra-regional studies of the British record (e.g. Mithen 1994), as opposed to elsewhere. However, the apparent conservatism within the Acheulean suggests that this technological industry involved strong rules, with variation amounting to constant changes to an overarching formula governed by social guidelines. Therefore, individuals may have been able to express themselves through tool manufacture, inserting the variability that is present within the archaeological record, but did not have the capacity to invoke lasting change to the parameters that governed the techniques used (Hopkinson & White 2005).

Behaviour and the social world of the Lower Palaeolithic

Our ability to infer the social behaviour of the archaic hominins present within the Lower Palaeolithic is limited by the archaeological record that we have available to us. However, there have been numerous attempts to build up a profile of *Homo erectus* and *heidelbergensis* and their social worlds. Here a general overview is provided which focuses on group size and interaction, movements of raw material and ranges, and evidence of fire use and the social arenas that they provide. The behaviour of *Homo heidelbergensis*, the hominin species associated with the British Acheulean, is discussed in further detail in the following section.

Determining group size within the Lower Palaeolithic is difficult given the small number of hominin remains available. Still, work has been conducted that seeks to predict neocortex ratios from the endocranial capacities of both living and fossil primates, which can then be used to estimate group size (e.g. Aiello & Dunbar 1993; Dunbar 1992, 1993; Dunbar 1998, 2003; Steele 1996). Such research has also been used to suggest possible periods in which language first began to evolve, based on it being a necessary adaptation to bypass limitations to group size caused by social grooming in its more conventional sense. In non-human primates, a maximum of 20% of the day may be given over to social grooming, with group sizes typically not exceeding 30-40 individuals even when grooming rates are at their highest (Dunbar 1993). Through language, multiple individuals can be affectively "groomed" at the same time, allowing group size to expand without demanding additional time devoted to grooming practices (Dunbar 2003). Dunbar (*ibid*.: 176-7) has suggested that, given *Homo erectus* appears to significantly exceed the limiting vale of 20% grooming time seen in non-human primates, some form of proto-language may have been present at this time, while fully modern, grammatical speech did not appear until modern humans evolved. This may be supported by evidence from Sima de los Huesos that suggests *Homo heidelbergensis* had auditory capacities within the range of modern humans and are clearly separated from chimpanzees (Martínez *et al.* 2004).

Steele (1996) has extended the analysis of group size, using both brain and body mass to estimate group size and home range based on whether is was equivalent to modern primates or undefended carnivore ranges (after Grant *et al.* 1992). Under this model, group size for *Homo erectus* is estimated at 107.6, while home ranges may vary from 3.7-10.6km (primate model) to 32.9-97.9km (carnivore model). The lower of these ranges are in keeping with data produced from raw material transfer studies (e.g. Féblot-Augustins 1999), with Gamble (1999) suggesting a landscape of habitat with a radius of c.40km, in which activities can be referred to as *local*, though White and Plunkett (2004) remind us that such movements may reflect more about the maintenance of stone tools as opposed to the social networks that we would like to see. However, it is through landscapes of habitat that individual hominins would have produced a social landscape, formed from their interactions with each other during the development of their extended social networks, thus also producing the surface structure of the group itself, which is considered to be the "summation of intersecting networks, based on the individual and represented by a variety of geographical scales" (Gamble 1999: 90). However, the Lower Palaeolithic archaeological record generally reflects the local nature of hominin life and does not provide the necessary evidence to support the notion of this social landscape (*ibid*.: 144). The absence of such extended social networks would no doubt have had repercussions for the ability of hominins to adapt to the environments of northern Europe, which Gamble suggests could only have been achieved by fragmenting group structures to minimise shortages of resources. However, it is important to not that absence of evidence of such social structures is not necessarily evidence of their complete absence.

Within the landscapes of habitat that hominins were part of, we are sometimes able to glimpse more defined aspects of hominin social life and behaviour. The evidence of fire use and hearths within the Lower Palaeolithic presents prime examples of such social arenas. Such areas are held by some to be where societies were created and maintained, becoming focal points for establishing networks of relationships between individuals (Gamble 1993; McNabb 2007; Stringer & Gamble 1998). Despite this, evidence for the use of fire is at best slim prior to 400 ka BP, with evidence coming from African sites (e.g. Koobi Fora, Chesowanja and Swartkrans), Gesher Benot Ya'aqov, Israel, and Bogatyri, north of the Black Sea (Bellomo & Kean 1972; Brain 2005; Brain & Sillen 1988; Goren-Inbar *et al.* 2004; Gowlett 1999, 2010; Gowlett *et al.* 1981). However, if evidence for fire is accepted this early, then Gowlett (2010) sees this a facilitator in diet change, increase in detailed knowledge of the environment and social collaboration, and may even be implicated in the growth of hominin brain size in the period between 2 and 1 ma BP.

Evidence for fire post 400 ka BP is stronger, with hearths present at Bilzingsleben II, Taubach, Schöningen 13 II-4 and Weimer-Ehringsdorf, Germany (Bratlund 1999; Kahlke *et al.* 2002; Mania 1991; Mania & Mania 2005; Theime 2005), and Vèrtesszöllös, Hungary (Vèrtes & Dobosi 1990). In Britain, evidence comes from the site of Beeches Pit, which also arguably provides the earliest evidence of an individual working by a fire (Gowlett 2006a, 2010; Gowlett *et al.* 2005; Preece *et al.* 2006). Other sites in Britain show evidence of burning, but this is limited to concentrations of charcoals and is suggested to be from natural fires (Pettitt & White 2012: 195). There is also the possibility of a hearth being present at Foxhall Road, as reported by Nina Layard (1903), which also had a number of artefacts clustered around it in a rough semi-circle (White & Plunkett 2004: 93) reminiscent of Binford's (1983) descriptions of how Nunamuit gather around campfires.

As Gowlett (2010) notes, fire has a number of functions that are both social and technological in nature. Not only would it have been instrumental in the transformation of materials, such as in cooking, but would have been provided an arena for face-to-face interactions between individuals. In addition, fire allows for the extension of the day, providing light and perhaps allowing for social "grooming" time to be extended outside of the hours that primates would normally be confined too. Gowlett (2006a) has also suggested, based on the evidence that the fires present at Beeches Pit were large conflagrations that were maintained for long periods, that strong social networks were required so that fire could be replenished from neighbouring groups if lost. However, others see this as a maladaptive gamble given the environmental conditions present within Britain during the Middle Pleistocene and instead suggest that this represents not an inability to kindle fire, but the necessity for individuals to maintain fire for warmth, safety and social entertainment (Pettitt & White 2012: 196), which would instead emphasise strong ties between individuals at the group level.

Given the evidence outlined above, it is apparent that the social world of hominins within the Lower Palaeolithic was centred at a local scale, situated within various landscapes of habit that built up their social landscapes. Group size was relatively small, as was their home ranges, as inferred from the movement of raw materials. Social interactions predominantly took place within the realm of the group, though there is perhaps evidence for wider social networks being in place at this time, and it is suggested that it is within more ephemeral localities, such as hearths, where the social world of the hominin individual can be most easily glimpsed.

THE CAPACITIES OF ARCHAIC *HOMO*

However, before any attempt is made to trace the individual in an endeavour to gain access to their social world, one must be aware of the capacities of the hominins that are encountered in the archaeological record and who are responsible for the material culture on which our analyses are based. Here I will specifically focus on *Homo heidelbergensis*, as this species of hominin can be correlated with the Acheulean handaxes that are to be the focus of the rest of this thesis (Hillson *et al.* 2010; Roberts *et al.* 1994; Stringer & Hublin 1999), and will explore the possibilities of projecting current social theories onto archaic hominins by discussing how much we can infer about the way they interacted socially.

McNabb (2007) has already highlighted the nature versus nurture debate that has been long running in Palaeolithic studies (see Hopkinson & White 2005; also summary in Ingold 2000), which exposes contrasting views as to whether culture overrides the individual, or is in fact re-created and maintained daily through the actions of individuals. This latter view appears to be the focus of the current socially orientated approaches to the Palaeolithic. But McNabb asks an important question – how would individuals relate to each other in a social sense (2007: 348)? He points to four different ways in which the Palaeolithic archaeologist can conceive of archaic hominins:

1) As more than just animals and, therefore, to some extent comparable to humans
2) As more animalistic than human
3) A combination of 1) and 2)
4) Finally, a unique species of animal that was the product of an environment, for which there is no modern comparison (see also White 1996).

As McNabb suggests, it is the third of these that most archaeologists prefer, although, as we shall see, many of their analyses are taken from the first or second of these categories. However, and here I am inclined to agree with McNabb's assessment, it is the fourth of these statements that is likely to prove true for *Homo heidelbergensis* and other archaic species, as there is no known modern analogue which provides an appropriate comparison. If this is the case, then it means that the projection of modern social theories, or even modern studies of animal behaviour, onto these species is unsuited to explain what are unique behavioural adaptations (*ibid.*: 348).

As noted above, it is common for studies to approach hominins from either the first (e.g. Gamble 1999, 2007), or second (e.g. Dunbar 1998; Dunbar 2003, 2007; Kohn & Mithen 1999) of these viewpoints. At the centre of many of these inquiries is the concept of establishing social relationships through performance and visual display (McNabb 2007). In essence this entails the engendering of social ties through the use of symbols, which must be understood by all parties involved. This is also the case with much of the social theory discussed previously – in order for individuals to be enchained within social structures, they must first understand them in order for them to manipulate and re-construct them. We currently cannot provide concrete evidence to support the claim that archaic hominins were able to comprehend and replicate such social signals, given that we have no modern comparison. This is a key issue in our understanding of how we approach the interpretation of *Homo heidelbergensis* and the extent to which they could comprehend social signalling. However, there has been a great deal of work aimed at providing some insight into the cognitive capacities of our ancient ancestors.

It is not surprising that archaeological research focuses primarily on stone tools as an indicator of cognitive advances, as this is, ultimately, the strongest source of evidence available (Holloway 1969: 399). Many have stated that the Acheulean handaxes produced by both *Homo erectus* and *Homo heidelbergensis* indicate an intellectual advance (Donald 1991; Mithen 1996b; Rossano 2009; Wynn 1981; Wynn 1995; Wynn 2002). However, as Wynn (1995) and Chase (1991) have stated, beyond the apparent imposition of form upon the finished artefact (c.f. Davidson & Noble 1993), we cannot infer that handaxes were used as symbols. What the evidence does indicate, though, is an increase in the working memory and analytical reasoning required to understand how reduction affected tool shape (Coolidge & Wynn 2009; de Beaune 2009; Mithen 1996b; Rossano 2009; Wynn & Coolidge 2007) and, perhaps more importantly, the possibility to display symbolic communication via social learning (see Wynn 1995).

Wynn's (1995) argument that the process involved in learning a knapping strategy requires not only observation of another individual, but also the ability to 'see' things as they see them, corresponds well with Dunbar's (1998, 2003, 2007) Social Brain hypothesis and *theory of mind*. This predicts that, based on a correlation between estimated group-size and neocortex volume, *Homo erectus* could achieve a third level of intentionality, while *Homo heidelbergensis* achieved a level of approximately four, the requirement for mutually understood social signals to be evident in material culture (Hallos 2005; McNabb 2007). Here intentionality refers to the ability to reflect on multiple states of mind (Dunbar 1998: Box 2). For example, with a second order of intentionality, one would be able to know that someone else knows something, while a third order allows an additional step, i.e. that one knows that someone else knows that someone else knows something. The consequence of this is that the Social Brain hypothesis places *Homo heidelbergensis* very close to modern humans in terms of intentionality (with adult *Homo sapiens* normally operating at level five) and affords them a limited linguistic capacity, which is required to overcome the stresses of social grooming (McNabb 2007). Therefore, they had the potential for social communication, though not for the manipulation of abstractions of thought, which occurs with the level five intentionality granted to modern humans (Dunbar 2004).

The above discussion also supports Mithen's (1996b) stance that technological intelligence is a separate construct from social intelligence from *Homo erectus* to the Neanderthals, with only modern humans able to link between these cognitive domains. If the stone tools that *Homo heidelbergensis* created cannot be considered as symbols, then this idea is reinforced. However, it still leaves us with the question of how these ancient hominins navigated their social worlds and whether they were using any form of socially created coding to do so.

Chase (2006) asserts that the emergence of social coding dates to the later Middle Pleistocene, based on a review of both anatomical and archaeological evidence, although he admits that this is only a *terminus ante quem* and states that "it [proves] frustratingly difficult to pinpoint the origins of socially created coding on the basis of research done to date" (ibid.: 117). McNabb (2007) has also considered the evidence for the transmission of social coding, under the guise of social knowledge and learning. He also admits that the data available is sparse, especially in terms of stone tools, though he reflects upon the case of Foxhall Road (see White & Plunkett 2004), which is discussed further in Chapter Four. However, the evidence points to an inclination for reproduction and mimicry as part of the learning process, which echoes Donald's (1991) hypothesis of mimetic culture.

Where McNabb and others (e.g. Gamble 1999; Mithen 1996b; Rossano 2009) see the greatest potential for glimpsing the social world of *Homo heidelburgensis* is within more ephemeral localities, such as hearths. Such areas would be important in maintaining social relations between individuals (Gamble 1993; McNabb 2007; Stringer & Gamble 1998) and provided arenas for social performances. However, the evidence for hearths throughout the Lower Palaeolithic is limited (see above), and almost non-existent in Britain (though see evidence from Beeches Pit in Gowlett 2005; Gowlett & Hallos 2000). The meagre evidence that does exist, though, indicates that some groups of *Homo heidelbergensis* were able to control fire to some extent (Roebroeks & Villa 2011), providing justification for the transmission of social knowledge amongst such groups. Whether we can prove this to be the case, however, remains to be seen, and leaves us with the consensus that unravelling this information from the evidence within the archaeological record is currently impossible (Chase 2006; Coolidge & Wynn 2009; McNabb 2007). What we are left with, then, is a species that is capable of negotiating their social worlds, but potentially in ways that cannot be compared to those we are currently attempting to project upon them.

TO ANALYSE THE HOMININ INDIVIDUAL

The question remains: how do we turn from the "theoretical storytelling" and realise a methodology that can be applied to Palaeolithic contexts? Such a methodology must be able the study the individual actor and, at the same time, inform us about that actor's ability to perform and maintain social relationships not only between individuals, but also with the wider social group. Starting from the premise that *Homo heidelbergensis* was able to achieve socially mediated transmission of knowledge, yet not in the same way that we do, this methodology must strive even further and aim to tease apart this hypothesis in order to test its strengths and weaknesses. We are then left with the question of where to begin.

Art, ritual and burial are obvious choices to focus upon when discussing the possibility of identity and sociality in the Palaeolithic. They are certainly foremost amongst the domains in which social performance may take place. However, any analysis is limited by the relatively short time span over which these occur. Most instances of Palaeolithic art and burial are confined to the Upper Palaeolithic and the realm of anatomically modern humans. Those possible instances of burial outside of this period remain a contentious issue (see discussion in Gargett 1989, 1999), with little evidence for burial at the time of *Homo heidelbergensis*. In addition, it is important to point out that grave goods and burial only reveals the social behaviour surrounding the interment, which is carried out by others, rather than the deceased individual we wish to associate it with. As for art, though it has been used to investigate social organisation (Balme & Morse 2006; Vanhaeren & d'Errico 2005) and individual behaviour (Henshilwood & d'Errico 2005; Mithen 1991; Sharpe & van Gelder 2006), the Lower Palaeolithic evidence is exceedingly sparse, with only a handful of artefacts available (e.g. Bednarik 1998, 2005; d'Errico & Nowell 2000; Dart 1974; Marshack 1997; Oakley 1973, 1981). However, these are often thought to be the results of curiosity rather than actual artwork (Chase 2006). The presence and apparent systematic use of ochre at Twin Rivers in Zambia (Barham 2002) may be a step further from this, indicating a possible semiotic role, but this has been argued to be indexical rather than truly symbolic in nature (Coolidge & Wynn 2009). Either way, we are currently limited to isolated elements that lead to theoretical musings, rather than the analysis of established relational links.

Therefore, any methodology must break away from these isolated events and aim to assess the habitual, day-to-day life-ways of ancient hominins. Equally it should not limit us to a specific genus or time period. The obvious focus for such a methodology is found in the tools that these hominins used, which represent the principal components of most Palaeolithic sites (Roe 1980: 108). Previous studies have mostly paid attention to refitting assemblages in order to answer their questions about individual behaviour and agency (Pigeot 1990; Pope 2004; Pope & Roberts 2005; Schlanger 1996). While this seems appropriate, due to the inherent investigation of fossilised acts and goals contained within the knapping sequence, we must strive to move beyond these isolated moments in time. To do so, any study must aims to incorporate the goal of isolating the individual's imprint in formal tools. Through these we can then analyse the flow of relationships between individuals at archaeological sites, which, in turn, will provide a broader picture of the exchange and enchainment of identity through material means. In addition, viewing social relations on such a fine grained level will also allow us to ask new questions about the social abilities of early hominins.

What we are left with is Gamble's (2004: 20) ultimate question: how do you unlock the social information in a handaxe? To answer this, we must begin to search for idiosyncrasies in tools and their manufacture that can be linked to an individual. This returns us to those earlier studies of the individual in material culture. Although they have been criticised for looking only at adaptive measures as explanations of variability (e.g. Cross 1983), they formed the basis for a study of the individual that is much more socially aware. Variability in stone tool form is not only the result of raw material and design habits, but also reflects the individual's own skill and ability to manipulate the knapping strategy in order to obtain the desired product (Bradley & Sampson 1986). This individual element can be linked to differences in motor habits, which causes subconscious variation in the execution of tool manufacture (Hill & Gunn 1977). White and Plunkett (2004) have been able to demonstrate evidence of knapping skill at the British Lower Palaeolithic site of Foxhall Road, which will be returned to in the next chapter. What is most important to note, though, is that this suggests the possibility of distinguishing an individual actor's imprint upon finished Palaeolithic tools.

Previous studies focused on both experimental archaeology (Gunn 1975; Tomka 1989) and prehistoric lithic materials (Gunn 1977; McGhee 1980) have also shown that there can be enough variation in the reduction strategy and scar pattern orientation of tools to separate individual knappers from one another. This presents two possibilities for approaching the individual element:

1) Through the analysis of fine grained refitting sequences
2) Through the analysis of final form of tools.

The first of these would allow for the precise reduction strategy applied by an individual to be established. By doing this, there is the possibility of ascertaining the following: which flakes are removed first and to what extent this reflects the knappers choices or inherent difficulties within the raw material; the quality of the raw material and whether this forced adjustments in knapping technique; and how the final form of the tool governed the overall reduction method. Because of the need to separate a variety of different elements, the knapping sequence would have to be analysed from a cognitive perspective (e.g. Schlanger 1996). This would then allow the individual's action to be exposed once the mechanical aspect has been stripped away, allowing a comparison across multiple refitting sequences to take place (Foulds 2010). Such a comparison would highlight whether it is possible to differentiate between individuals through the analysis of the reduction sequence alone.

However, while refitting sequences have the potential to contain more information about individual agency and hominin goals, we cannot rely upon them alone. As has already been pointed out, these represent isolated instances in the Palaeolithic record, thus limiting our analysis. Therefore, we must not ignore tools that lack refitting flakes. If Gunn (1975) is correct and an individual imprint is left behind on each stone tool that the knapper creates, then a similar methodology can be produced. Gunn has highlighted eight possible ways through which knappers may leave traces of their individual signature on a stone tool (see Chapter Three). These can be applied to refitting material, but, more importantly, they may also allow the finished tool to be incorporated into such studies.

Of course, any methodology for studying the individual in the Palaeolithic would need to be tested. We often accept that tools can stand as proxies for individuals (Gamble 2007; after Pope 2002). However, we are currently unable to distinguish between individuals in the Palaeolithic. Therefore, each and every biface or reduction sequence we find must be interpreted as the product of a separate individual's agency, but to what end? We still don't understand the motivations or intentions behind them. As a result, we need to test not only whether an individual's imprint on a tool can be recognised, but also if that imprint can be traced on other tools within an assemblage and if so, what it actually means. This is impossible to do within Palaeolithic contexts, as the individual knappers involved are no longer there to indicate which tools they created or why. As a consequence, we must turn to experimental archaeology as a viable alternative. Because the knappers in an experimental sample are known, we can clearly see whether they leave a discernable mark that can be followed across all the tools that they produce, allowing us to trace groups of tools back to their maker. Although replicating techniques is not the same as replicating technology (Dobres 2000: 150) the attribution of specific tools to a particular individual using such an experimental approach would suggest that there is the possibility this could be repeated for Palaeolithic artefacts. In addition, an experimental study would allow for the methodology to be refined prior to any application to Palaeolithic contexts.

SUMMARY

This chapter has provided a discussion of the history of theoretical approaches to Palaeolithic archaeology and has highlighted a number of potential problems with the application of social theories to Palaeolithic contexts. It has shown how we cannot escape from out past thought processes, no matter how much we criticise them, and that these still have a bearing on how we conduct research today. It has both considered the social approaches that currently deal with agency and identity, and underlined certain issues with their application to deep prehistory. Finally, it has proposed how archaeologists may move these approaches forward through the analysis of individual imprints within stone tools.

The introduction of such a methodology has the potential to remove the current generalisations about individuals that are seen in Palaeolithic research. Through it, we may be able to study aspects of hominin social relations that, at present, exist only in the realms of theory. However, it may also indicate that the nature of the Palaeolithic record precludes the existence of individual signatures, even if we were able to trace imprints under experimental conditions. This would means that material culture and the agency contained within it could not be studied in finer detail, resulting in any discussion of Palaeolithic social relationships being reduced to theoretical storytelling, limited only by our imaginative potential. Either way, this study becomes part of a greater movement that aims to place the processual versus post-processual debate in the past (for example see Millson 2010 and papers therein), and strives to produce a method of analysis that combines science and theory in a reciprocal fashion.

CHAPTER THREE
TOWARDS A METHODOLOGY FOR STUDYING THE INDIVIDUAL

INTRODUCTION

The previous chapter outlined the theoretical background to the study of the individual in the Palaeolithic. It highlighted several issues within previous research, all of which must be resolved before the individual can be considered to be a viable analytical unit, not just within the Palaeolithic, but also in wider Prehistoric studies. To this end, it proposed that a methodology must be devised that is capable of tracing an individual's imprint across multiple finished tools, as well as the isolated and fine grained records provided by reduction sequences. If the results of such a methodology are positive, then the socially orientated theories that have been put forward as explanations for variation in the material record may be tested, such as whether knapping practices are homogeneous or heterogeneous across multiple individuals over a single occupation phase or "living" floor, or exploring the notion of craft specialisation within Palaeolithic social groups. However, a negative result would indicate that our theories continue to represent our own ideas and interpretations of the archaeological record, rather than quantifiable facts to be tested. Therefore, we may have to accept that these are untestable hypotheses, limited only by our imaginative potential.

In order to answer the call for such a methodology, this chapter outlines a series of experimental techniques that aim to explore whether an individual's idiosyncrasies can be detected and traced within the archaeological record. The focus of these techniques are the stone tools that make up part of the day-to-day life ways of the hominin individuals that we wish to study. First, however, a critical review of previous methodological approaches to the study of the individual must be conducted, which will lay the groundwork for the implementation of the methodology discussed in this chapter.

METHODOLOGICAL APPROACHES TO THE INDIVIDUAL

Several methodological approaches to the analysis of individual in lithic artefacts already exist in the literature. These have approached the study of the individual from a variety of perspectives, but mainly they consist of refitting lithic débitage and the analysis of final tool form. However, while each has proven successful to a degree, their application to wider archaeological studies has yet to occur. Whether this is due to the methodology applied being more suited to a specific question or problem needs to be addressed. Therefore, a discussion of these approaches is presented here. This discussion is broken down into two separate parts: the first deals with studies that have used refitting as an analytical tool; the second addresses methodologies that centre on the analysis of idiosyncrasies in final tool form.

Analysing the individual through refitting studies

The use of refitting as an analytical tool for tracing the individual is, arguably, the most common approach used in lithic studies. It relies on the fact that each percussive act in the knapping sequence is an expression that is intrinsically linked to the individual knapper. Therefore, the knapping sequence is made up of a series of fossilised acts that reflect the goals of the knapper in the production of the finished tool. The idea that such acts can be compared throughout refitting sequences and idiosyncrasies produced by differences in physiomotor characteristics, which are equated to skill, can be traced lies at the heart of this form of analysis. The most famous of these studies are those conducted at the Magdalenian sites of Etiolles and Pincevent, France.

The individual at Pincevent and Etiolles

Refitting studies at Pincevent began with the work of Leroi-Gourhan and Brézillon (1966, 1972, in Schurmans 2007). However, the use of refitting to present evidence of individual knappers is a more recent occurrence. Refitting of lithic débitage from the production of blade cores has shown that differences in knapping skill can be distinguished at Pincevent, as well as at the site of Etiolles (Bodu *et al.* 1990, Julien *et al.* 1992, Karlin *et al.* 1993, Pigeot 1990). This work uses the *chaîne operatoirè* approach and indicates how the chain of production conforms to pre-existing concepts prevalent throughout the group, which are then modified by the individual knapper's idiosyncrasies throughout the reduction process (Karlin *et al.* 1993). An intuitive approach to such operational sequences has allowed three 'technical levels' to be demonstrated at Pincevent (Bodu *et al.* 1990), representing levels of skill from apprentice, through mediocre, to good/expert. At Etiolles, the apprentice level has been further broken down into a series of apprenticeship levels, from novice through to experienced (Pigeot 1990).

The categorisation of reduction sequences into these technical levels is based on the presence or absence of a variety of criteria, based on experimental studies (see Table 3.1). For example, an inexperienced or novice knapper may be represented where the quality of the blades produced is poor, while stable production of high quality blades is taken to indicate an expert. In addition, evidence of apprentice knapping is taken to be an indicator of the presence of children or adolescents, based on ethnological evidence (Bodu *et al.* 1990; Pigeot 1990). This has lead to the suggestion that the knapping at Pincevent represents the product of nuclear families (Bodu *et al.* 1990) consisting of a variety of members with different skill levels. The idea of using low skill levels in knapping to suggest the presence of children has also been used at other sites, such as the Middle Palaeolithic occupation of Maastricht-Belvédère, Netherlands (Stapert 2007), and the Upper Palaeolithic site of Solvieux, France (Grimm 2000). However, it should be remembered that evidence for limited skill might equally indicate the actions of inferior adults.

Although this method of analysis has highlighted a number of useful criteria that can be used to distinguish between knappers of different skill levels, it has only revealed *random* examples of individuals, even if they suggest that the characteristics of a series of artefacts and reduction sequences could be used in a systematic attempt to identify knappers on the basis of their products (Karlin *et al.* 1993: 331-2). The attribution of refitting ensembles to an individual is based upon the assumption that correlations in the knapping strategy reflect the individual in question. Karlin *et al* (1993) also notes that it is more difficult to identify individuals with lower skill levels, due to the fact that idiosyncratic technical behaviour is less marked. In addition, there is the possibility that the products of an individual produced at varying stages of apprenticeship may be interpreted as the work of separate individuals. Therefore, it appears that, while providing useful information that may be built upon, such a method of analysis is yet to trace individual idiosyncrasy across multiple knapping sequences.

Sequence progression and the individual

Van Peer (2007) has presented another form of refitting analysis that claims to be able to show elements of individual idiosyncrasy in Levallois reduction sequences. This methodology aims to establish the precise order of flaking used throughout the knapping strategy, by analysing the clockwise and anticlockwise progression of flaking around the Levallois core, as well as the relative intensity of flaking in a particular section of that core. Through the compilation of such data across multiple refitting sequences, it is possible to objectively compare reduction sequences. As a result, the order in which actions take place during reduction appear to be a key means of identifying an individual's knapping idiosyncrasies.

While this approach attempts to move beyond the subjective analysis described above through the use of an objective methodology, it can be demonstrated that the interpretation of the data is very similar. Van Peer's (2007: 99) comparison of the reduction sequences from Makhadma-6 are described as quite similar, although two typologically different reduction methods have been used. Coupled with the spatial context of the site and the size of the lithic scatter (c.f. Cahen & Keeley 1980), Van Peer has suggested that this indicates the products of a single individual and, thus, traces the manufacture of both cores back to one knapper. This is used to emphasise that idiosyncratic morphologies are produced, and that these are the results of the individual's personal way of approaching a problem.

While this method introduces another potential indicator of idiosyncratic variability, it must be noted that the interpretation of the sequence progression data amounts to an assumption that similarities must indicate the product of the same knapper. However, the results of the analysis do suggest that individual idiosyncrasies may override morphological differences that are used in current classification systems. In this way, it emphasises a similar point made by White and Jacobi (2002), who have suggested that variation in *bout coupé* handaxes may in fact stem from individual idiosyncrasy, indicating that a differentiation between this tool 'type' and other flat butted cordiforms is likely to be false.

Spatial patterning of lithic débitage

The final example of locating individuals through the refitting of lithic débitage suggests that spatial patterning of lithic material can be used to indicate the number of knappers present. Cahen and Keeley (1980) have carried out such an analysis at the site of Meer II, Belgium (Figure 3.1). Studying the *in situ* activity area at C IV, they have shown how space constraints indicate the maximum number of knappers that could have been present. Given a $1m^2$ seating area and a conservative $2m^2$ working area, they have suggested that the $11m^2$ area at C IV would allow for no more than four individuals, while introduction of a hearth to this area would further limit the number to make three individuals a more reasonable estimate. Further analysis of the space surrounding the hearth has shown that there are a series of concentric bands of débitage, the patterning of which is explained as the result of two individuals seated next to the fire. The overall interpretation is an area that could accommodate up to three individuals, though the presence of two is much more likely.

They have supported their claim through further evidence, namely a series of borers that are suggested to turn in an anticlockwise direction when used, possibly by a left-handed individual (Cahen & Keeley 1980; Cahen *et al.* 1979). In addition, the presence of several refitting blocks that display 'simplified' reduction techniques, clockwise borers and links via movement to C Ia, another location on the site, are taken to indicate a second individual, given that "it seemed unlikely that three different individuals would have started a piece of work in C IV only to finish it in C Ia" (Cahen & Keeley 1980: 178).

Again, the analysis is subjective, something which Cahen and Keeley (*ibid.*) readily admit, given that the evidence cannot be shown to be more than circumstantial in nature. Their methodology shows that the number of individuals may be interpreted to an extent, but an accurate estimate of the precise amount of knappers was not possible, leading them to conclude that the work present at C IV was the result of "not less than two and probably not more than three individuals" (Cahen & Keeley 1980: 179).

Analysing the individual through final tool form

The analysis of individual idiosyncrasy within the final form of lithic artefacts is much less prevalent when compared to those studies that make use of refitting. However, these have also explored the possibility of tracing individuals within both experimental and archaeological assemblages, and, in one particular case, have claimed more success than the methods previously examined. Examples of such methodologies will now be discussed.

Stylistic variability

One common method of identifying the presence of different individuals using lithic artefacts is analysing the stylistic variability within an assemblage. Although stone tools are likely to present fewer attributes that can directly be correlated to style, due to factors such as raw material variability, it has been suggested that differences in motor skills amongst individuals would introduce a certain amount of idiosyncratic variability to an assemblage (Hill 1978; Hill & Gunn 1977; McGhee 1980). McGhee (1980) has applied these assumptions to Independence I stone tool assemblages at Port Refuge in the North West Territories, Canada. By examining artefacts from individual features at the site, McGhee suggests that marked differences can be seen amongst the tools in terms of knapping ability and the amount of care applied to the manufacture of the tool. Making burins the focus of analysis, he has stated that uniformity in tools from the same dwelling features possibly presents evidence of a single individual responsible for their creation (*ibid.*: 449). However, features that show less distinct similarities in tool form are, instead, suggested to be the result of several knappers working at the same location. The overall result of this analysis is the supposition that individual knappers made similar artefacts in a variety of different ways, resulting in noticeable differences in final tool form, which can be attributed to idiosyncratic style and a sense of the knappers 'own way of doing things', as opposed to the idea that morpho-functional considerations constrain the strategy used in tool production (Van Peer 2007: 101). It also suggests that there is a greater degree of freedom for individual decisions regarding the choice of knapping strategy to use, even if they have a shared preconception of how the end product should look and how it should be made (McGhee 1980: 452). Therefore, the only shared ideas are likely to be the functional aspects of the tool.

Similar claims for artefacts that have been created by the same individual, or show an element of idiosyncratic style, have been made for a variety of archaeological sites, even stretching to Acheulean assemblages such as Elveden (Ashton & White 2003), Foxhall Road (Ashton & White 2003; Layard 1904; White & Plunkett 2004), Caddington (Catt *et al.* 1978) and Boxgrove (Matt Pope, pers. comm. in McNabb 2007: 367). However, the main problem with all of these examples is that the idea that idiosyncratic style is present within the assemblages discussed is merely a supposition based upon the interpretation of similarities in tool form. Indeed, McGhee's (1980) analysis has been criticised for its absence of uniform criteria that are able to clearly show the presence of a single knapper, as well as a tendency to interpret the tools within single features as the product of one individual (Cross 1983). Yet, while it is easy to argue against these suppositions, it is equally hard to refute them, due to the fact that we have no means available to test whether one hypothesis or the other is correct. This serves to emphasise the need for a methodology that is able to distinguish between individual knappers and also trace their imprints through final tool form. Only through such a methodology will these examples be either proven correct or shown to be false.

Flake scar analysis

Other methods that have tried to establish the presence the individual within the final form of a tool have approached this problem through the analysis of patterning in flake scar morphology. Two of these approaches will be discussed below. Although these methods study the same variable, the two approaches analyse this variable from very different perspectives.

The first of these two methodologies to be discussed is Young and Bonnichsen's (1984) cognitive approach to the study of stone tools. This is based upon the assumption that material products cannot be understood without reference to the processes involved in their creation. Under these terms, the final form of a stone tool cannot be fully interpreted without understanding the relationship between cognition, behaviour and the finished implement. It also realises the potential for individuals to generate idiosyncratic responses to specific problems, based upon their previous experiences.

Through a series of controlled experiments, Young and Bonnichsen have shown that it is possible to interpret morphological attributes on finished artefacts, such as flake scars, and attribute them to specific technological decisions made by the individual knapper involved in the artefact's creation. However, comparison of experimental artefacts made by Callahan and Bonnichsen indicate that an almost identical number of actions are used during the production of tools that are similar in both size and shape, despite differences in the reduction strategy used and the length of time require to manufacture the finished product. Furthermore, when comparing individual morphological units produced using the same technique, for example pressure thinning or shaping, no discernable differences were noted that differentiated the two knappers. However, Callahan also used techniques that were not used by Bonnichsen during the experiment, which introduced a measure of difference into their tools. However, in terms of individual analysis, the suggestion that knappers may choose to use similar reduction techniques that cannot be differentiated without prior knowledge of the individual involved may present a fundamental issue for any analysis of individuals in the archaeological record. This must be addressed in the implementation of a methodology that aims to trace individual idiosyncrasies in lithic artefacts.

The second methodology is Gunn's (1975) analysis of flake scar morphology on bifacial tools. Like Karlin *et al* (1993), Gunn identified a number of sources of variation that might indicate differences between individual knappers. Compiled from discussions with Don Crabtree, a total of eight possible indicators of idiosyncratic style were suggested: variation in levels of platform preparation, flake scar orientation, bulb of percussion, ripple marks, termination, striking accuracy, striking angle and the thickness of the flake removed. Using an experimental approach, Gunn tested the validity of one of these indicators, namely the orientation of flake scars, not only for identifying the products of individuals, but also tracing an individual's imprint across multiple tools.

The method used by Gunn stands in stark contrast to those previously discussed. Rather than introduce a subjective method to the analysis of the problem, he instead used a complex technique aimed at quantifying the variation displayed by the flake scars and allowing an objective analysis of the resultant data. The technique involved in Gunn's experiment is termed 'laser diffraction', another name for optical Fourier analysis, which has also seen biological (Oxnard 1973), geological (Davis & Preston 1971; Preston *et al.* 1969) and geographical (McCullagh & Davis 1972) applications.

Optical Fourier analysis consists of transforming a black and white film image to its visual Fourier equivalency by passing light first through the image and then through a series of lenses, before allowing the power spectrum of the transform to be captured, either on photographic film, or another form of light sensitive surface (Gunn 1975, 1977; Oxnard 1973: see Figure X). In the case of Gunn's experiments, the images used were photonegatives from trace drawings of the scar patterns from a series of replica bifaces, as well as one additional archaeological sample from the Simon Site Cache, Idaho (see Butler 1963). A light sensitive surface measured the concentration of the Fourier spectra produced, which were used to analyse the orientation of flake scars within the scar patterns studied. Through the application of multivariate statistics, Gunn was able to show that the scar patterns clustered according to the knappers who created them, with a small degree of overlap. Gunn used these results to suggest that scar pattern orientation presents enough variability to separate out some knappers, with other variables, such as the knapper's skill and experience, influencing the tightness of the clusters produced (Gunn 1975: 60).

Gunn's experiments are possibly the most important, methodologically, out of those discussed here, due to the fact that they present an quantitative methodology that was not only able to distinguish between knappers, with a degree of certainty, but also group their products together. However, it is not free from criticism. Bodu *et al* (1990) noted that the approach is focused upon a single lithic product and, thus, does not take into account data regarding the sequence of tool production. In addition, the experiment required that the modern knappers involved all produce replica bifaces based on a common template, using the same raw material, flaking technique and similar percussors. The result is the removal of much of the additional variability that complicates a real archaeological assemblage, where each knapper is free to select the materials suited to the required task, or, alternatively, may be constrained by the materials available (Ashton & McNabb 1994; White 1998a). By placing such limits on the experimental assemblage, Gunn reduced the overall variability to that of the individual. Therefore, this introduced a bias into the results that had the effect of emphasising the methodologies suitability for ascertaining individual knappers.

Cross (1983) has also criticised Gunn's methodology on two counts. The first is that the clustering present in Gunn's analysis may not be indicative of different knappers, but instead may reflect variation in the percussors used by each individual. Although Gunn (1975) states that soft sandstone hammerstones were used by all knappers, differences in the mass and resilience of these implements may generate flakes with characteristic proportions, thus masking the individual motor patterns that the technique claims to detect (Cross 1983: 92). In addition, the problem of resharpening or staged production by separate individuals would also present problems for this methodology, as it is not capable of discerning between a single knapper's imprint and the product of multiple "hands" (*ibid.*: 93). While both of these points are true, and need to be considered, the former may be less of an issue. Gunn notes that Knapper 3 in the group of modern knappers also chose to use a billet, in addition to the sandstone hammerstone, though of what kind he does not say. If we were to see a distinct difference due to the products of different percussors, then we would expect the bifaces produced by this knapper to present a unique cluster. However, this does not occur (see Figure 3.3). Instead the bifaces produced cluster together within the same range as those produced by the other modern knappers, and directly overlap with Knapper 1's products. While it could be argued that the introduction of the billet to the reduction sequence by Knapper 3 could have modified the resultant scars in a way that mimicked the effects of the percussor used by Knapper 1, two other points of information make this less likely. The first is that the two knappers were in the middle of the skill range (1-6) given by Gunn. Therefore, it may have been likely that the products of these knappers clustered closely together due to similarities in their skill levels. The other issue is that one of these knapper's was left-handed. Again, the clusters would be expected to diverge, rather than group together. Gunn (1975, 1977) has noted this, and has shown that these knapper's can be separated by plotting the results according to additional canonical variables produced through the multivariate analysis. Finally, experimental analysis of the effects of both hammer mass and velocity on flake morphology has shown that flakes are almost entirely determined by platform size and the exterior platform angle (Dibble & Pelcin 1995; Dibble & Whittaker 1981). Therefore, it appears that the variability in flake scar orientation may in fact be more heavily influenced by the motor behaviour of the individual knapper.

As a result, Gunn's methodology presents a possible objective approach to the individual, but it is problematic in that it has not been adequately tested, nor applied systematically to archaeological assemblages. Further analysis that explores all forms of variability that may be introduced into an assemblage is needed in order to establish the validity of the results from this experimental approach.

Summary

The methodological approaches to the individual that have been discussed above have outlined two approaches to the study of lithic artefacts. The first seeks to explore the reduction strategy used in the production of finished artefacts in terms of behavioural attributes that reflect the choices and decisions made by the individual knapper. Examples of such attributes are the selection of suitable raw material, the ability to solve problems throughout the reduction of the raw material, the sequence of reduction used, and even the spatial patterning produced by the lithic débitage.

The second approach focuses upon the finished tool. Methodologies that study the final form of an artefact explore morphological variations at the microscale in order to establish evidence of individual motor behaviour and the decisions and choices made in the production of the artefact that remain imprinted upon it. Two of the approaches discussed above have used variation in flake scar morphology to indicate such variables.

What is clear is that there are a variety of possible indicators that may relate to the individual knapper involved in the production of a lithic artefact. However, few of the approaches to the interpretation of these indicators provided reliable and uniform criteria that enable an objective and quantifiable analysis. This problem must be addressed if the individual is to become a viable unit of analysis within investigations of the Palaeolithic material record.

AN EXPERIMENTAL METHODOLOGY FOR ANALYSING INDIVIDUAL IDIOSYNCRASY IN STONE TOOLS

As has been discussed above, an objective and quantifiable methodology that is able to identify the individual knappers within an assemblage is necessary in order to move beyond subjective analysis of the archaeological data. From the previous studies of the individual, two common approaches have emerged. The first is the use of refitting to reconstruct the reduction sequence and analyse and compare the decisions made by the knapper in the production of finished tools. The second is the analysis of variability in final tool form in order to establish which traits are indicative of an individual's idiosyncrasies. Within this second approach, there is also a tendency to focus on the two dimensional morphology of the artefact, leaving aside considerations of variation in three dimensions. As the analyses of the reduction sequence have also shown that variations within what is essentially a three-dimensional process can be attributed to the individual, it is important to consider the possibility that variation in the overall morphology of the finished tool may also contain elements of the individual's imprint.

Also, it is imperative to consider all possible sources of variation that may be affected by an individual knapper's approach to the production of a stone tool. Based on the discussion above, the following variables have been identified, which may be used to identify differences between individuals:

1) *Platform Preparation*: The presence or absence of platform preparation is taken to be the result of the knapper's own decision to use this approach within the reduction strategy. It is possible that some will prepare all flakes, while others will only use this technique to solve specific problems. In addition, complete absence may indicate limited understanding of this concept, which may possibly be interpreted as inexperience, given the context of the tools studied. This feature, however, is only to be found on detached flakes and, thus is limited to study of the reduction sequence.
2) *Bulb of Percussion*: Both the positive and negative bulbar scar may vary, in terms of size, extent and depth, dependant on the force applied in the percussive act. However, variation in this attribute can be influenced not only by the individual, but also by the percussor used, as well as the stage of the reduction technique being employed.
3) *Ripple Marks*: Undulations on the ventral surface of flakes, which are also seen in the negative scars produced by flake removal, may also be influenced by the individual's approach to reduction. Again, this variable may also be affected by the percussor used and the stage of manufacture at which the flake is removed. Thus, it is unlikely that ripple marks truly reflect the individual's approach to reduction.
4) *Termination of Flakes*: The termination of flakes can vary from feathered, representing the ideal removal, to stepped, hinged and plunging overshoot, which may all be attributed to mistakes on the part of the individual knapper (Andrefsky 2005; Butler 2005; Cotterell & Kamminga 1987; Whittaker 1994). While this could be attributed to the level of skill present, it should also be noted that

the quality of the raw material will influence production procedures (Jones 1979) and, hence, the morphology and termination of flakes. Therefore, use of this variable would need to be qualified by examining the reduction sequence for other evidence of the knapper's abilities.

5) *Striking Accuracy*: The accuracy at which the knapper is able to deliver a blow to the raw material will also determine the morphology of the flake produced. Inaccuracy will result in the occurrence of hinge fractures and crushed platforms (Whittaker 1994). However, it appears here that this is the *interpretation* of a measure, as opposed to a measure in itself.
6) *Striking angle*: Variation in striking angle will produce differences in both the platform and bulb of percussion present on a flake. However, measuring angles on lithic material can be an inaccurate procedure (Dibble & Bernard 1980).
7) *Thickness of the Flake*: Some knappers will create thicker flakes than others. However, as has been mentioned, flake morphology can is affected by platform size and angle (Dibble & Pelcin 1995; Dibble & Whittaker 1981), and it must be demonstrated that the knapper aimed to control these during the reduction process.
8) *Raw Material Selection*: The selection of raw material can be indicative of the knapper's knowledge concerning the desired end product and also their ability to choose appropriate nodules that will flake easily and provide few problems, though the availability of raw material may constrain this choice. Dibble (1991) has discussed how variation in an assemblage can be affected by the proximity of raw material sources and topography, which can directly influence the choice and acquisition of workable material.
9) *Reduction Sequence Progression*: As discussed by Van Peer (2007), the sequencing of the reduction strategy may provide links to the individual involved. This consists of cataloguing the rotation of the artefact throughout the reduction process.
10) *Flake Scar Orientation and Morphology*: And Young and Bonnichsen (1984) and Gunn (1975, 1977) have shown, flake scar morphology is influenced by the knapping procedures used in the final stages

of artefact production, which, in turn, are influenced by the knapper's decisions in the creation of the finished tool. Also, if Gunn is correct, the patterning of flake scars on the finished tool may provide a way to quantify the number of knappers present within an assemblage, as well as tracing the tools back to their creators.

11) *Tool Form*: The overall morphology of the tool represents the knapper's final goal and is inherently representative of a hominin's actions in the pursuit of this objective.

In addition to those traits mentioned above, some other indicators of knapping idiosyncrasies have been identified. These include the amount of breakage seen amongst the débitage produced, possibly indicating shattering of a flake due to the percussive act and, hence, the force used, as well as differences in the number of flakes produced during each stage of manufacture. However, there are also issues with these potential idiosyncratic markers. Flake breakage may be attributed to a number of factors, least of all the knappers control of the reduction process. For example, increased incidence of flake breakage could be due to the raw material quality, the reduction stage, whether the knapper chooses to sit or stand during reduction (though this may also indicate choices on the knapper's behalf) and, finally, a host of post-depositional activities. Likewise, the stage of reduction is difficult to assess. Speth (1972) has already noted difficulties in distinguishing between hard- and soft-hammer modes of production, given that the prominence of the bulb of percussion is likely to be dependent on the angle of impact, the platform quality and the force applied, rather than the percussor itself. Bradley and Sampson's (1986) experiments in the use of hard-hammer stones for the thinning and finishing of Acheulean handaxes also add to the problem of distinguishing between the use of a hard or soft hammer in the reduction process.

What we are left with is a suite of possible methods and indicators that might point to any imprint left behind by an individual both in the finished tool and the reduction strategy used to make that tool. The problem then becomes ascertaining which of these is the most suitable for tracing individual knappers within an assemblage. To tackle this, a series of three experimental studies were devised with the aim of exploring their potential for investigating the individual. These studies aimed to approach this question using each of the methods mentioned, with the results analysed using a reflexive approach, designed to reflect upon and explore the reasons behind both positive and negative outputs. These three experiments were broken down into:

1) The analysis of refitting sequences and the recording of traits that are commonly claimed to represent knapping idiosyncrasies.
2) The investigation of idiosyncrasies in the three-dimensional morphology of finished tools.
3) Testing the potential for the knapper's imprint to be contained within the variation of scar patterns on the surface of the finished tool (after Gunn 1975).

The methodology behind each of these experiments is described below.

Refitting the individual

Refitting lithic débitage allows for the precise reduction strategy used by a knapper to be established. This then allows for the variety in the knapper's own choices to be revealed. For example, which flakes were removed first? How did their choice of raw material affect the strategy applied? And how did the desired form of the finished tool influence the sequence, or visa versa? Due to the need to isolate such a range of elements, the knapping sequence must be approached from a cognitive viewpoint (e.g. Schlanger 1996; Young & Bonnichsen 1984). This is necessary in order to remove the mechanical aspect of the flaking process and expose the individual's actions in the production of the knapping strategy (Foulds 2010). This can then be compared across multiple refitting sequences with the aim of linking reduction strategies to their creators.

Previous methods that employed such techniques have often done so using a qualitative approach, despite defining rigid criteria for distinguishing differences in the method of reduction. In order to provide an objective analysis of the reduction sequence, a quantitative set of criteria has to be established. These can then be used in combination with a cognitive approach, with both the quantitative and qualitative methods complimenting each other.

Such a set of criteria was established using eight variables that have been suggested to be linked to knapping idiosyncrasies. These variables include:

1) The percentage of flakes with hinge/step fracture terminations
2) The percentage of flakes with missing platforms
3) The percentage of flakes with platform preparation
4) The percentage of fractured flakes
5) The percentage of clockwise rotations of the nodule
6) The percentage of anticlockwise rotations of the nodule
7) The percentage of unknown rotations
8) The percentage of removals from the same location.

Three of these variables were selected due to the fact that they have been suggested to be indicative of knapping skill (1, 3 and 4). The number of missing platforms was also recorded, as this directly affects the amount of platform preparation that can be seen within each sequence studied. The final four variables all describe the rotation of the object between each flake removal and, thus, represent the manipulation of the raw material throughout the knapping event. Clockwise and anticlockwise rotations[2] refer to the direction of rotation following one removal before striking the next flake. The unknown rotation variable was established for any instances where the precise direction that the object was moved in could not be seen. Such instances may be caused by an inability to follow the knapping procedure due to an incomplete refitting sequence, or due to the fact that the knapper jumped to a new area, meaning that the direction of rotation could not be accurately recorded. Finally, the variable for removals from the same location

[2] Rotations were recorded from the knapper's perspective, as if the knapper was turning the tool in hand.

was suggested for instances where little or no rotation is seen, and the knapper either proceeds with intensive reduction of an area, or attempts to correct a mistake.

For each of the refitting groups studied the number of times that each variable occurred throughout the reduction sequence was recorded. The total count for each variable was then converted to a percentage value in order to address the fact that reduction sequences often present varying amounts of flakes that can be refitted successfully and enable a comparison between refitting groups. However, it should be noted that, while the use of percentages enables sequences of difference sizes to be compared, large differences in the number of flakes contained within each refitting group might result in the analysis being skewed. This is addressed further in the interpretations of the refitting material contained in Chapter Six.

The data collected was analysed to present clusters of refitting sequences, which may, in turn, relate to the individuals involved in their production. In order to produce such clusters, a principal components analysis of the data was carried out using the FACTOR program within the SPSS statistics package for Windows (SPSS 17, release 17.0.0). This analysis extracts a series of components from the eight variables that account for the total variation seen within the sample. The results of the principal components analysis were then plotted as scatter diagrams. These scatter diagrams were explored to show potential grouping of tools and to determine what factors caused of these clusters. The principal component results were also analysed using hierarchical cluster analysis to determine whether this quantitative statistical technique was able to produce groups that are indicative of the knappers involved in the production of the refitting sequences studied, or clustering due to other factors. Again, this cluster analysis was performed using the SPSS software package. Finally, these analyses were interpreted in conjunction with the cognitive assessment of the refitting sequences in order to aid in the understanding of the results.

The individual in three-dimensions

The analysis of lithic artefacts in three-dimensions and the application of three-dimensional modelling to lithic assemblages is becoming commonplace within archaeological investigations of the material record (Clarkson *et al.* 2006). Therefore, it was decided that an exploration of three-dimensional form was needed in order to supplement and build upon the methods described by Gunn (1975, 1977). In addition, this would allow the degree to which three-dimensional form is influenced by the individual knapper's technique and skill to be established. To achieve this, artefacts were modelled in order to produce a complete record of their surface in three-dimensions.

For the purposes of this study, artefacts were scanned using a Mephisto Complete optical scanner (4D Dynamics, release 1.8.0202), which is able to achieve accuracies of up to 0.06mm. The resultant output produced point-cloud data made up of coordinates in three-dimensions (see Figure 3.4). Scans were processed using Demon 3D (Archaeoptics, release 1.5.2) in order to remove any erroneous points. In some instances, meshing of multiple scans was required in order to produce a complete model. Again, this was completed using the Demon 3D software.

Rather than produce a full three-dimensional reconstruction of the artefacts studied, each surface was scanned separately and the resultant data was imported into the ArcMap package within ArcGIS (ESRI, version 9.3). Using this software, the points cloud data was converted into a raster format, allowing the surfaces of the artefacts to be treated as if they were landscapes. In all cases, handaxes were orientated so that their tips faced 'north' while the butt faced 'south'. The three-dimensional data was then analysed using two Spatial Analyst Tools: Slope and Aspect. In order to study the angles of flake removals across the surface of the artefacts, the Slope tool was used to calculate the gradient for each point within the point-cloud data (Figure 3.5). Using the analogy of landscapes, the artefacts surface is treated in much the same way as a hill and the angle of the slope across the tool's topography is measure in degrees. The number of points was calculated for each five-degree increment in the gradient, between 0^o (flat) and 90^o (vertical), in order to produce a total of eighteen variables for analysis. In a similar way, the orientation of the flake scars across each face was analysed in three-dimensions using the Aspect tool. Again, each artefact is treated as a landscape and the direction that its topography faces is analysed. The orientation of each point within the point-cloud data was recorded in degrees and the points were then assigned to one of eight variables corresponding to the eight cardinal directions (Figure 3.6).

A count of the total number of points assigned to each variable was produced and converted into a percentage value in order to standardise the data. This was done to address differences in the size and shape of the artefacts, which ultimately influences the total number of points recorded during the three-dimensional scanning process. The use of percentage values to standardise the data removes this size factor and allows results to be produced that are not heavily weighted in favour of this variable. Principal component analysis was then applied to the data using the SPSS program FACTOR. This allowed a series of components that explained the majority of the variance to be extracted from the variables under study. The principal component results were explored using scatter diagrams in order to look for potential clusters of tools and investigate what factors may have caused these groups to appear. Hierarchical cluster analysis of the principal component results was also used to determine whether a quantitative statistical analysis is able to produce clusters that reflect the individuals involved in the production of the tools, or results in groups that are due to other factors.

In addition to conducting an analysis of the surfaces of each tool, an attempt was made to analyse them as whole artefacts. Therefore, the data from associated surfaces was summed and an average was produced that represented the tools as whole units. This process was carried out for both the aspect and slope data. The whole unit data was analysed in the same manner as the surface data, using principal component analysis to extract the components that explain the majority of the variance and interpret any clustering that appeared.

The individual in two-dimensions

The final methodology is the analysis of scar patterns on the surfaces of formal tools. This follows from Gunn's (1975) original experimental study of scar patterns on bifacial tools using optical Fourier transform analysis. As discussed above, Gunn asserted that differences in the intensity of the Fourier transform spectra produced using this methodology could be attributed to variation in the orientation of flake scars removed in the thinning and finishing stages of tool manufacture.

As Gunn (1975: 41) states, the process used is complicated and involves passing a complex wave of light through the photonegative image of a scar pattern trace followed by a series of prisms and lenses, which separate the original wave into a series of simple wave forms that can be recorded (Oxnard 1973: 176-7). This optical method of producing the Fourier transform spectra was preferred over performing the operation using a computer due to issues surrounding the digitisation of the information in the light wave (*ibid.*: 176). However, advances in modern computing mean that this process is no longer as complex. As a result, this methodology was revised and updated through the use of a computer program, which replaces the physical equipment used in Gunn's original analysis.

The computer program used in the analysis presented in this thesis was designed to return the two-dimensional discrete Fourier transform of an image containing a scar pattern trace, computed using a fast Fourier transform algorithm based on the FFTW library (see Frigo & Johnson 1998; MathWorks n.d.). A complete account of the code used in this software can be found in Appendix One. In order to implement the analysis of the scar patterns, both sides of each of the tools studied were photographed using a Fujifilm 8.0 megapixel digital camera. These photographs were imported into Adobe Photoshop CS4 (Version 11.0) and the scar patterns were traced with the aid of a graphics tablet (Figure 3.7a). All of the scar pattern traces were converted into 500 by 500 pixel images in order to remove variability in size and increase the ability to perform a comparison of the tools. The images were then loaded into the computer program, which converted the scar pattern traces into Fourier transform spectra. The program then calculates the intensity values for each spectrum within an 180^{o} arc divided into five-degree segments (Figure 3.7b). This produced data across a total of thirty-six variables (Figure 3.7c), which are comparable to those produced in Gunn's

(1975: Figure 4) analysis, though this only extracted thirty-two variables due to limitations of the equipment used. Only half of the spectrum was analysed in each case, due to the fact that the spectra produced are symmetrical. The extracted data were subsequently analysed using principal component analysis in order to extract those components that explain the majority of the variance for further analysis. The extracted components were plotted as scatter diagrams in order to explore the data further, establish whether any clusters of tools could be seen, and deduce the reasons for such clustering. In addition, hierarchical cluster analysis was used to determine whether this quantifiable statistical technique was able to produce meaningful groups that reflected the knappers involved in the production of the assemblage.

In his original analysis, Gunn suggested that the variables extracted from the Fourier spectra corresponded to the orientation of flake scars within the scar patterns he studied (Figure 3.8). However, as Gunn accurately states (1975: 41), the intensity values of the Fourier spectrum actually represent the amount of lines within the scar pattern trace that are orientated in a particular direction. For example, long rays within the spectrum indicate more lines in the scar pattern orientated in that particular direction, while shorter rays indicate fewer lines. Gunn took this to mean that if there were a large number of lines orientated in a particular direction, then this corresponds to a higher number of flakes removed in that direction. However, there are a number of issues with this assumption, which primarily revolve around determining whether high instances of lines orientated in a particular direction are truly indicative of flakes orientated in the same way. The main problem stems from the fact that scar patterning is the result of multiple flake removals, which overlap and truncate previous flake scars throughout the course of reduction. As a result, high values for a particular orientation variable may not be indicative of the orientation of flake scars, but simply represents a high degree of lines within the scar pattern orientated in that direction. An example of such a situation is demonstrated in Figure 3.9. Therefore, the suggestion that the variables under study correlate directly to the orientation of flake scars cannot be demonstrated in all cases. However, study of scar patterns using Fourier transform analysis is able to demonstrate similarities in the overall patterning seen and it is likely that this is what Gunn was able to detect. This then suggests, based on Gunn's results, that knappers may produce highly similar scar patterns.

Due to the realisation that the data does not accurately reflect flake scar orientation, the analysis presented in this thesis will discuss and interpret the results with the understanding that the variables account for the orientation of lines in the scar patterns and, by extension, the overall patterning of flake scars observed on stone tools. In addition, the analysis will endeavour to explore whether the methodology is able to trace individual knappers, especially in assemblages that display a higher degree of variability compared to the experimental assemblage that Gunn originally studied.

SUMMARY

This chapter has discussed previous methodological approaches to the analysis of the individual and has outlined a variety of potential markers of knapping idiosyncrasies in stone tool form and manufacture. Using these markers a series of experimental techniques have been defined that will be used to explore whether knappers can be traced within the stone tool assemblages discussed in Chapter Four. These methodologies build upon previous analyses of the individual, which attempt to analyse both the reduction strategies employed by hominins and the final form of their tools. The results of these analyses are discussed in Chapters Five to Eight of this thesis and will either demonstrate that idiosyncrasies linked to specific individuals can be clearly seen within lithic material, or highlight other factors that mask the knapper's input into the creation of lithic tools. Either way, the results will have strong implications for our understanding of the individual within Palaeolithic contexts, as well as the theoretical interpretations of the archaeological record that are currently in vogue.

Chapter Four
Materials Selected For Analysis

Introduction

Having defined the methodology in Chapter Three, a suitable sample of lithic material was required that was able to test the limits of the techniques discussed. To this end, the Acheulean handaxe was chosen for two main reasons. First, the Acheulean handaxe presents a bifacial tool type, similar to that used by Gunn in his experiments. Second, the use of Acheulean assemblages would step beyond the Upper Palaeolithic, which has been the focus of many studies that aim to explore the individual in Palaeolithic contexts (e.g. Gamble 2007; Grimm 2000; Karlin *et al.* 1993; Pigeot 1990). It is very rare to see such theories applied to the Lower Palaeolithic (though see Chapter Two and references therein). In addition, the Acheulean presents a period in which the hominins present displayed levels of intentionality that approached those seen in modern humans today, suggesting that these they were capable of the understanding and adhering to social norms (Dunbar 2003). Their activities revolved around the utilisation of smaller home ranges and localised landscapes of habitat that made up their social worlds, adapting to a range of environmental factors that in turn would have influenced how they maintained and developed their social relationships (see discussion in Chapter Two). It is arguably at this point in prehistory that we may begin to see a development towards the more modern social structures that are suggested to be in place with the rise of anatomically modern *Homo sapiens.* As a result, understanding the individual and how they related themselves to their social worlds is of prime importance to a continued expansion of how we approach the understanding of the development of our own species and our won sociality. Therefore, it was deemed appropriated to select the Acheulean for analysis, in order to both push back this boundary that appears to surround studies of the individual, and also to demonstrate whether social theory as it currently stands can be readily applied to this period of prehistory.

For the purposes of testing the methodology, a number of British Acheulean sites were selected for study: Foxhall Road, Suffolk; Boxgrove, West Sussex; and Caddington, Bedfordshire. These are discussed in detail below. All of these sites display evidence of *in situ* lithic scatters, suggesting that the artefacts within them were deposited within a relatively short timeframe in comparison to the general palimpsest nature that is seen at other sites in the Lower Palaeolithic (e.g. Stern 1993, 1994). This, of course, is highly important for the application of any technique that aims to trace individual idiosyncrasies, though it must be noted (and is discussed further below) that despite having occupational contemporanity, sites such as those discussed in this thesis still suffer from an unresolved issue of chronological resolution (Conard & Adler 1997). In addition, and perhaps more importantly, all the sites studied have been suggested to present evidence of individual knappers, displayed either through comparison of finished tools, or through similarities within reduction techniques. As a result, this strengthens the argument for the inclusion of these assemblages. If the experimental methodology is able to detect an individual's imprint, then the validity of these claims may be tested. However, before discussing the material chosen for study, it is imperative to provide some background to the nature of the Acheulean as a stone tool culture and what it can reveal about individuals and Palaeolithic social life, as well as discussing the handaxes that will be studied.

DEFINING THE ACHEULEAN

The Acheulean is the name given to the stone tool industry produced by archaic hominins from 1.6 million years ago until the first occurrence of the Mousterian, around 250,000 years ago. It has a wide geographical distribution, stretching from South Africa to Northern Europe, and from West Africa and the Iberian Peninsula to India and Nepal (Goren-Inbar & Sharon 2006; Schick & Toth 1993; Sharon 2007). Its earliest occurrence is in East Africa (Asfaw *et al.* 1992) and appears within the majority of Europe around 500,000 years ago, along with the first sustained occupation by hominins (Roebroeks 2006; Roebroeks & van Kolfschoten 1994). Though there are numerous sites that suggest an earlier occupation, such as Atapuerca (Carbonell *et al.* 1995), Prezletice (Fridrich 1989), Stránská Skála (Valoch 1987) and, more recently, Pakefield (Parfitt *et al.* 2005; Stuart & Lister 2001) and

Happisburgh (Parfitt *et al.* 2010), many of these sites have been criticised (e.g. Dennell & Roebroeks 1996; Roebroeks & van Kolfschoten 1995a; Westaway in press), leaving the Acheulean as the earliest evidence for prolonged occupation within this continent.

The industry itself was named after the site of St. Acheul, France, where its defining tool type, the handaxe, was first identified as a prehistoric tool by Boucher-de-Perthes (1847-1864). Such implements, along with other core and flake tools, are commonly held to have been introduced by *Homo erectus*, in Africa, while its appearance in Europe is normally attributed to *Homo heidelbergensis* (Klein 1999). It is the handaxes from British Acheulean assemblages that will be the focus of this thesis.

The Acheulean handaxe

The Acheulean handaxe has been called one of the greatest enigmas of the Lower Palaeolithic (Wymer 1982: 102). They were the first artefacts to be officially recognised as tools by the nineteenth century antiquarians and microwear analysis on Acheulean handaxes from Hoxne has shown that their function was probably for butchery (Keeley 1980), though the application of this technique has been criticised (see discussion in Yerkes & Kardulias 1993) and has not been extensively applied, especially to the British material (Taylor 2011). They have been defined as bifacially worked tools that are characterised by a cutting edge that extends around the circumference, sometimes with the exception of the butt (Kleindienst 1962). They often present bilateral symmetry, and appear in a range of shapes and sizes. The definition of handaxes by attributes such as these has resulted in its classification as a typological entity, resulting in a common image of the handaxe that is based on a "classic" form (Ashton & McNabb 1994). However, there is a great degree of variability, which has been eloquently displayed by Wymer (1968, see Figure 4.1).

Variability in form

The handaxes of the British Lower Palaeolithic have commonly been divided into pointed and ovate forms, first by Evans (1860, 1897) and later through Roe's (1968) metrical analysis. This parallels a similar division in the

European evidence shown by Bordes (1961). These two classes subsume within them the much broader range of variation that is suggested by Wymer (1968). Originally, it was thought that variation in shape indicated differences in knapping tradition and, thus, was a marker of cultural affinities to an evolution of form that progressed from cruder examples through to the more elegant ovate handaxes (e.g. de Mortillet 1891). Such a system of unilinear evolution in stone tool form was untenable, however, given the impossibility of fitting many sites within its boundaries. Therefore, parallel phyla of evolutionary development were instituted, though the idea that shape and simplicity of tools indicated a cultural expression continued (Ashton & McNabb 1994: 182).

Roe's (1968, 1981) metrical analysis of the British data has indicated that the division between ovate and pointed forms is a reality and his further seven subgroups also attest to the variability present within the British assemblages. These were suggested to be the result of inherited knapping traditions resulting from different cultural groups that were present within the Lower Palaeolithic. However, Roe could not see a predictable pattern of variation emerge from his study, which demonstrated a weakness in the use of shape as a chronological or cultural marker (Ashton & McNabb 1994: 183). More recent evidence has emphasised this, with the presence of Boxgrove, dated to MIS 13, presenting a range of highly symmetrical ovate forms during the earliest Acheulean in Britain, accompanied by the acknowledgement that such sites now pre-date the Clactonian industries, which lack handaxes (though see McNabb & Ashton 1992, 1996), and were taken to be pre-Acheulean in nature (White 2000). McNabb *et al*. (2004) have also suggested that social groups had little influence over the form of material culture through the analysis of assemblages from the South Africa Acheulean, suggesting that this was expressed in some other way and, as a result, that tools were not used to signal with. However, while imposed form by social groups has been argued against, the idea of a group-centric, many-to-one, or concerted mode of cultural transmission has been posited for the Acheulean, which is suggested to account for the slow rate of cultural evolution in the Lower Palaeolithic and limited variation between groups (Lycett & Gowlett 2008).

Functional and stylistic constraints have also been used to explain the variability in the Acheulian (Gowlett 1998). Though some have argued that style and function present a dichotomy, Sackett (1982) suggests that functional decisions can amount to passive stylistic choices. Therefore, the choice to use one tool form over another can be seen as a stylistic act (Gowlett, 1998: 61). Glynn Isaac focused on this issue while examining the Acheulean at Olorgesailie (Isaac 1977), showing that variation in the numbers of different tool types present reflected differences in the function of each site within the complex. However, demonstrating this for handaxe morphology was more difficult, leading to the suggestion that differences in shape and size of these tools resulted from drift in localised traditions. Porr (2005) has also discussed the issue of style, referring to 'material style', i.e. the imposed form given to objects by humans, and 'dynamic style', which equates to similarities in the actions performed amongst groups of individuals within face-to-face social interactions. Through the consideration of these, Porr suggests that it is this dynamic style that is the more socially important of the two, with the objects implicated in social interaction given less weight that the social activities in which they were used. This is used to explain the lack of innovation and extensive variation in the Acheulean, as if handaxes were of greater important than social interaction, then we would expect to see a greater diversity in form. However, Porr does make the point that hominins concentrated on refining and expanding upon existing features in the elaboration of a communally defined project, suggesting that mastery of handaxe production may equate to a command of the set of social relations in which they were involved (*ibid*.: 80). Hence, the handaxe may present opportune candidates for materialising social relations, as they appear to have stood within the centre of hominin social life (Porr 2000).

Variability in Acheulean handaxes has been approached more recently from two main perspectives. The first has been put forward by McPherron (1994, 1995), who suggests, in a similar way to Dibble's (1984, 1987, 1995) examination of Mousterian scrapers, that the final form of the tool is representative of a continuum in reduction prior to final discard of the tool, moving from pointed to ovate forms as the reduction intensity increases. This stance builds upon the 'finished artefact fallacy' promoted by Davidson and Noble (1993), noting that the artefacts that we recover from the archaeological record do not necessarily represent the intended shape that the knapper aimed to obtain. However, there is evidence within the Palaeolithic record that contradicts McPherron's argument to some extent, namely the GTP17 scatter at Boxgrove. Here, refitting of the flakes produced in the reduction of a flint nodule have shown that the resultant artefact was an ovate handaxe, the shape of which has been confirmed by taking a cast of the hollow at the centre of the refitted nodule (Pope 2002: 150-3). In addition, flakes at the site of Caddington that were refitted by Smith (1894) suggest the knapper aimed to produce an ovate tool (Figure 4.2). These examples suggest that pointed handaxes were not necessarily the initial choices that were then reduced to form ovates (contra McPherron 1994). However, this does not deny that these ovate handaxes may have been modified from their original form prior to its discard.

The second approach emphasises the role that raw material plays in governing the knapper's reduction strategy (Ashton & McNabb 1994; White 1995, 1998a). White (1998a) has shown that Roe's groups are valid, but, rather than being evidence of knapping traditions, reflect variable responses to the size, shape, and quality of the local raw material sources that hominins exploited. Therefore, the knapper was able to select a strategy that would produce an optimal end product given the size and shape of the nodule used, emphasising that hominins were able to approach the production of handaxes with a flexible repertoire of techniques. The overall results of this analysis showed that ovate handaxes represent the preferred form, made on large and robust nodules, while pointed handaxes were generally made on raw material blanks that conditioned the knapping strategy, usually obtained from secondary sources. However, the overall suggestion is that hominins were more concerned with producing a working edge upon the tool, rather than a desired shape.

Whether one of these hypotheses is more valid than the other has yet to be proven. However, it is recognised that both reduction intensity and raw material components have an important role in the variability of lithic tools, along with a suite of other factors that includes tool attrition, settlement type, palaeoclimate and faunal exploitation (Rolland & Dibble 1990). Indeed, McPherron (2000) acknowledges the role raw material plays in producing the patterns observed in the archaeological record, while White (2006a) has accepted that reduction processes may be at the core of cleaver production in Britain, with these tools suggested to represent handaxes that have been truncated by additional flaking (c.f. Bordes 1968). This then emphasises the ability of archaic *Homo* to solve problems through a flexible approach. In addition, it gives weight to the argument that, although there appears to be a standardisation in form, it is the hominin knapper that begins the introduction of variability into the tool, as it is the knapper that must make the decisions concerning how a specific problem should be resolved. However, the role that both reduction and raw material play in introducing further variability is important and must be carefully considered. If the role these two factors played in the production of variability is greater than that introduced by the individual knapper, it is likely that they will mask any idiosyncratic imprint that might be present.

Of course, there are other explanations of variability that must also be considered. Winton (2005) has discussed the relevance of skill in the production of handaxes and makes the important point that any discussion of variability that does not include specific reference to skill is ultimately flawed. Consideration of knapping skill is especially pertinent, given that differences in skill result from the individual hominin themselves. The imposition of symmetry upon handaxes is also commonly debated in regards to Acheulean variability. Such symmetry appears to be the result of selective factors, as opposed to neutral variation (Lycett 2008). Symmetry may have resulted from its functional role, caused by the need to produce a sharp cutting edge. However, there appears to be a lack of a significant relationship between symmetry and function in most respects, though there is some support for increased frontal symmetry leading to increased butchery effectiveness (Machin *et al*. 2005; 2007). As a result, there may be other factors that effected the imposition of symmetry on handaxe form. Both Pelegrin (1993) and Edwards (2001) have related symmetry to a developing sense of aesthetic appreciation, but Kohn and Mithen (1999) suggest a more social explanation that is linked to mate selection. While a conclusive explanation for the imposition of symmetry is not as yet forthcoming, what can be shown is that this may have important implications for the understanding of both hominin behaviour and the individual, especially when looking for idiosyncratic features. Examples of such idiosyncrasies in imposed symmetry have been shown at both Elveden (Ashton & White 2003) and Boxgrove (Pope *et al.* 2006), where hominins appear to have purposefully recreated flaws or mistakes present on one side of a handaxe by using careful knapping on the other. Such examples emphasise the fact that symmetry was obviously an important factor, which, certainly in these cases, may go beyond simple functional constraints.

Knapping strategies

As part of the methodology outlined in Chapter Two aims to explore idiosyncrasies in the reduction process used in the formation of a finished tool, it is necessary to discuss the knapping strategies that are relevant to the production of the Acheulean handaxe. A great deal of work has been carried out in order to understand this subject. Therefore, a brief summary will be provided.

The reduction of a nodule in order to produce a handaxe is often broken down into stages in the literature, as attested to by experimental knapping, though some would view the process as a continuum (see discussion in Bradbury & Carr 1999). Three main stages have been identified; *roughing-out*, followed by *thinning and shaping*, and finally *finishing* (after Newcomer 1971). The first of these stages involves the removal of protrusions from the raw material and bifacial flaking along the edge to provide general shape to the nodule, thus producing a rough-out. This stage is usually carried out through the use of hard hammer technique, producing thick flakes with pronounced bulbs of percussion that display varied amounts of cortex on their dorsal surfaces. Approximately 40% of the flakes produced during handaxe manufacture may be attributed to this early stage (Bradley & Sampson 1986), with Newcomer (1971) suggesting no more than ten to twenty flakes being created as a result. Early Acheulean handaxes may be finished during this stage of the reduction process (Schick & Toth 1993: 240), though the more refined handaxes of the British Lower Palaeolithic would generally proceed into the next stage.

Thinning and shaping of the handaxe took place with the use of soft hammer percussion, possibly using either antler or bone (Bordes 1947; Coutier 1929; Crabtree 1967; Newcomer 1971), although Bradley and Sampson (1978) have asserted that a quartzite pebble may be used in conjunction with carefully prepared platforms, stating that it is the choice of mode rather than the hammer that determines the characteristics of the flake. The main goal of this stage of reduction is the removal of any further disconformities from the surface of the rough-out, while thinning the tool and providing the final shape. The flakes produced are normally thin, with diffuse bulbs of percussion, and display the scars of previous thinning removals on the dorsal surface. Flakes produced with a soft hammer often have a lip between the butt and the ventral surface. Approximately 50% of the reduction sequences is accounted for during this reduction stage (Bradley & Sampson 1986), with the number of flakes produced being comparable to the initial roughing-out stage. Newcomer (1971) notes that the overall desired shape is clear at the end of this stage, unless the handaxe is to be an ovate, which requires further thinning and shaping to take place.

Finishing consists of producing the final shape of the handaxe, as well as obtaining a sharp cutting edge. Again, this stage may be carried out through the use of soft or hard hammers. The flakes produced are comparable to those formed by *thinning and shaping*, although most are demonstrably smaller and thinner. Bradley and Sampson (1986) attribute 10% of the flakes produced to this stage, although Newcomer (1971) suggests that this stage is the most variable, and may produce up to 30 flakes.

There are several archaeological analogues that support these reduction experiments. Newcomer (*ibid.*) has shown that flakes from various British Lower Palaeolithic sites are comparable to those produced in his experiments. In addition, the GTP17 refitting nodule from Boxgrove (Figure 4.3), which consists of 53 flakes, appears to conform to the stages that Newcomer describes, although the resultant handaxe was removed and finished elsewhere (Pope 2002). Further evidence from Boxgrove also indicates that hominins used a variety of percussors, ranging from organic (bone and antler), to soft-stone (cortical flint) and hard-stone hammerstones (rolled flint beach pebbles) (Wenban-Smith 1999). Analysis of the archaeological material shows that organic percussors were used for thinning and finishing handaxes, while the others were used during the initial roughing-out stage. In support of this argument, there is also evidence of the hominins at Boxgrove preparing bone and antler in anticipation of their use as percussors in lithic reduction, and provides an example of the creation of tools used to make further tools (Roberts 1996; in Wenban-Smith 1999). Experimental knapping also indicates that flake attributes are determined not by the mode of knapping (c.f. Bradley & Sampson 1986), but rather by the percussor itself.

Finally, there is evidence that hominins did not carry out all the stages of tool manufacture in one sitting. While some have characterised archaic *Homo* as having a '15-minute culture' (McCrone 2000), emphasised by the abilities of modern knappers to produce components of the Acheulean toolkit in under fifteen minutes, Hallos (2005) has argued against this statement. She has shown that, while some sites do display evidence of use and discard almost on the same spot, for example at Boxgrove (Austin *et al.* 1999) and Caddington (Bradley & Sampson 1978), refitting studies from four Middle Pleistocene sites in Europe indicate that transport of handaxes can occur at several stages of the knapping process. This has been used to argue that handaxes were not always produced in response to an immediate requirement and, thus, may indicate evidence of planning depth that has, until recently, been denied to ancient hominins. It also emphasises that for modern knappers the goal is the replication of the tool, while for hominins, it is to produce something serviceable, which will in turn be used in other activities. Further evidence of complexity in artefact production within the Acheulean has been presented by Pope's (2004) analysis of material from the GTP17 horse butchery site at Boxgrove. In this case, evidence from the refitting scatters recovered indicates that tested nodules and roughouts were introduced to the area and a series of at least four handaxes were produced during a short-lived period of activity. However, the lack of associated tools demonstrates that, following this knapping event, the tools were removed from the site. This of course introduces possibilities for curation of technology and tool re-use, which stresses a consideration of resharpening in the maintenance of handaxe efficiency (see McPherron, 1995). In addition, it emphasises the interpretation of Lower Palaeolithic assemblages through an understanding of the contextualised decision making undertaken by the hominins present (Pope, 2004: 46).

IMPLICATIONS FOR APPLICATION OF THE METHODOLOGY

Having discussed the Acheulean and the handaxes that form the focus of this study, it is important to consider the implications of their analysis using the proposed methodologies. It has already been noted that the variability within artefacts begins with the actions of the individual. However, we must question the extent to which the individual is able to control the variability of artefact form over other factors, such as raw material constraints. As Cotterell and Kamminga (1987) have shown through experimentation, there is no way for a knapper to control the angle of force during the flaking event. Therefore, once the raw material has been struck, the detachment of the flake is dependant on the resultant force travelling through the nodule. This force will be affected by two main variables, although a suite of other factors will also contribute to the flaking process, such as those described by Pelegrin (1993). The first is the skill of the knapper in landing an accurate blow that will result in a flake being detached. The second is the quality of the raw material and whether this will allow the force to travel unimpeded through it. As both poor knapping skill and poor raw material quality may both result in the development of step and hinge fractures, it is important to determine which of the two variables is likely to account for occurrences of these knapping mistakes.

In addition, White's (1998a) suggestion that raw material shape and size may have a large part to play in final tool form also has strong implications for the application of the methodology. If these factors do play a part in constraining or in some cases even freeing-up the knapper's reduction choices, then they paradoxically reduce and enhance the amount of idiosyncratic variability introduced by the knapper, by forcing/allowing them to adopt alternative knapping strategies to achieve a maximal return. This may result in a single knapper producing entirely different reduction sequences, as well as highly variable final tool forms, given the initial characteristics of the raw material chosen for each handaxe.

Hallos' (2005) study of handaxe reduction and transport may also highlight potential problems. It is assumed that the refitting component of the methodology will work best with the presence of sequences that are as complete as possible. If the reduction sequence is broken into stages, during which the knapper moves position, then the ability to excavate entire reduction sequences may prove difficult. Also, each stage in the reduction sequence arguably represents alternate sets of goals that the knapper is aiming to achieve. For example, in the *roughing-out* stage, the aim is to remove protrusions and generally shape the raw material prior to the more systematic thinning conducted in the subsequent stage. Therefore, it is likely that the reduction strategy used by the knapper will change to reflect changing goals throughout these stages. As a result, if any of these stages are missing from the refitting débitage then the results of the analysis are likely to be greatly affected. Due to such issues, a direct approach to Palaeolithic assemblages cannot be justified. Therefore, it is imperative that the methodology's ability to locate any individual idiosyncrasy in both tool manufacture and final form is tested. The only way to do this would be to implement an experimental control, which will now be discussed.

An experimental control

As was noted above, a methodology cannot be built directly from Palaeolithic artefacts, as we cannot make any a priori assumptions about the identity of the individuals we are attempting to identify. If the techniques described were to be interrogated in such a manner and produced positive clusters of tools, it would be impossible to confirm whether such clusters reflected a shared idiosyncratic imprint, or, alternatively, some other source of variation. As the identities of the knappers involved in any Palaeolithic assemblage are unknowable, an alternative is needed to test the methodology. As has already been suggested, experimental archaeology presents the most viable alternative.

As the methodology is something of an experiment in itself, one that aims to show whether an individual imprint can be traced across both the reduction sequences and formal tools found in a Palaeolithic assemblage, it is necessary to have a control that can be referred back to. Indeed, an element of control is essential within all experimental studies (Amick *et al.* 1989). To this end, a replica assemblage was used. This replica assemblage presented a range of tool shapes, but had minimal constraints placed upon it, in order to show whether other forms of variability, such as raw material, have a greater signature than the knapper's own idiosyncrasies. Therefore, knappers were not required to conform to the use of a specific type or quality of flint, nor were they asked to produce a specific range of forms. Instead they were asked to produce tools according to their own desires, using raw material and reduction strategies as they saw fit. This lack of constraints would, hopefully, enable an assemblage to be produced that mimicked a Palaeolithic assemblage as closely as possible. In addition, by allowing the knappers to choose the form of the tools they created, rather than forcing them to conform to a set example, such as was done by Gunn (1975 and see above), it would be possible to show whether a knapper's imprint could be traced not only across tools that are morphologically similar, but also very different.

However, the most important facet of this replica assemblage is that the number and identity of the knappers was known, and the methods designed to identify individuals could therefore be tested. Yet, this knowledge may also be hindrance. If the identities of the knappers are known while interpreting the results, then there is the possibility of introducing a bias into that interpretation, resulting in establishing patterns that would not be seen if such knowledge was unavailable.

Therefore, a further control was established; the first phase of analysis was conducted under 'blind test' conditions, with only one of my supervisors knowing the identity and number of knappers involved in the production of the replica assemblage. This was implemented by denying access to the relevant information regarding the associations between knappers and their tools until after the results had been interpreted. In addition, the total number of knappers involved in the experiment was also removed from the evaluation of the findings. This aimed to simulate the conditions that would be present in an archaeological assemblage. Therefore, any interpretation of the results under these conditions would be similar to that produced if an actual Acheulean assemblage were being studied. However, the results could subsequently be compared to the withheld information in order to judge the accuracy of the methodology and indicate where refinement is needed.

The replica assemblage involved in testing the methodology presented above was produced by a total of six knappers, all of whom were requested to provide a series of handaxes by Mark White. In this way I was removed entirely from the creation or design of the replica assemblage, ensuring that the controls outlined above were established prior to applying the methodology.

THE ASSEMBLAGES

The methodology was applied to a total of four Acheulean assemblages. Of these four, one was the replica assemblage formed from a series of modern imitations of Acheulean handaxes, which was designed to be a control. The remaining three assemblages studied have all been collected as part of archaeological excavations at Acheulean sites that have been stated to be *in situ*. In addition, all three of these sites share another common feature; the purported claim that there are handaxes or reduction sequences that share characteristics which may be attributed to a single individual's idiosyncratic imprint (Ashton & White 2003; Catt *et al.* 1978; Layard 1904; Matt Pope, pers. comm. in McNabb 2007; White & Plunkett 2004). Therefore, these sites make for appropriate choices, as if the methodology can be proven to accurately distinguish between individual knappers, the possible evidence for traceable individuals at these archaeological sites can be established beyond the speculation that it currently amounts to.

A description of all four of the assemblages now follows. This details the handaxes and refitting material that was studied, as well as providing a brief overview of the site context and excavation methods used for each of the archaeological assemblages, in order to justify their inclusion within this study.

The replica assemblage

The replica assemblage used in this study consists of 26 handaxes produced by six knappers (see Table 4.1) and has been described in brief by Foulds (2010). In addition, a crib sheet displaying these handaxes is included at the rear of this volume for the reader's reference. This assemblage was used to test the methodology prior to its application to the Palaeolithic assemblages. A more detailed description of this assemblage will now follow.

The purpose of this assemblage was to provide a controlled evaluation of the methodology, by employing a series of handaxes made by a group of modern knappers. In order for it to bear as close a resemblance to a Palaeolithic assemblage as possible, and to reduce any bias that might be introduced, such as is suggested by Gunn's (1975) approach, no restraints were placed on the knappers' choice of raw materials, techniques or style. Knappers were asked to produce handaxes according to their own level of skill, the properties of the raw material chosen and, as one of the knappers eloquently put it, their mood. The aim was to create an almost organic assemblage that, while not directly comparable to what is found at Palaeolithic sites, would provide as close a substitute as possible. In addition, if this approach resulted in the production of a range of handaxe morphologies, it would also allow the possibility of testing whether the technique used by the knapper transcended the shape of the finished product.

Performing a 'blind test'

In order to perform a rigorous test of each of the proposed analytical methods, the identities of the knappers and which tools they had produced for the assemblage remained a secret while the analysis took place. In this way, the replica assemblage was approached under blind test conditions, with the aim that this should mimic the problems presented by a Palaeolithic assemblage. The most obvious of these problems is that we do not know who made which handaxe in the Palaeolithic record. Therefore, by not revealing the links between knappers and their tools prior to the analysis, the results could not be interpreted with the known values of "who made what" already at hand. The outcome of using this approach was that the results of the analysis could be subsequently compared with the actual relationships between the knappers and their tools, thus confirming whether the conclusions of each technique were correct or flawed.

The handaxes

The 26 handaxes that formed the assemblage were all created using flint, though the raw material presents a range of patination and quality (Figure 4.4). There is an almost even split between pointed and ovate types, with fifteen ovate and eleven pointed handaxes. The assemblage has been further broken down according to Wymer's (1968) typological method for comparison to the Palaeolithic assemblages discussed below.

The majority of the handaxes were made by just four of the knappers, with the remaining two only contributing one handaxe each. Whilst this information was only revealed after the results of the methodology had been interpreted, it emphasises that the replica assemblage would not only allow for the possibility of tracing an individual knappers imprint across the tools they produced, but also whether a knapper producing a single tool can be separated from the rest of the tools present.

The refitting material

From the whole replica assemblage, a cross section of eight handaxes was selected and provided with their resultant débitage, which the knappers had been requested to retain (Table 4.2). The handaxes chosen present a range of sizes and shapes, though there is, again, an even split between pointed and ovate forms (Figure 4.5). In addition to the eight handaxes from the assemblage, one additional sample of débitage was supplied with no associated handaxe. The importance of this additional sample is that, due to the blind test conditions that had been introduced, it could not be assumed to be the product of an additional knapper. Instead, it was possible that the débitage was produced by one of the knappers involved in the production of the other handaxes. It would also provide a way to assess whether the absence of the tool directly affects the interpretation of the refitting sequence. Once the results were revealed, however, it was shown that this débitage was produced by one of the knappers involved in the creation of the assemblage, resulting in a total of three individuals producing the nine refitting sequences studied.

Boxgrove, West Sussex

The Middle Pleistocene site of Boxgrove, West Sussex, is one of the most famous and important Palaeolithic sites in Europe, if not the world. It is situated on a raised beach, designated the Westbourne-Arundel (formerly Goodwood-Slindon) Raised Beach (Pope 2002), which stands some 40m above modern sea level (Roberts 1986; Wymer 1999) and which can be traced for some 30km east-west (ApSimon *et al.* 1977; Roberts *et al.* 1995; Woodcock 1981). The archaeological site at Boxgrove lies within the confines of a large quarry, Amey's Eartham Pit, worked by the Amey Roadstone Corporation for the purposes of gravel, sand and chalk extraction (Roberts 1986). Its location in relation to the other sites addressed in this study is displayed in Figure 4.6. Boxgrove owes its fame to two key factors. The first is the discovery of a hominin tibia, ascribed to *Homo heidelbergensis*, in Trench 5 of Quarry 2 during excavations in 1993 (Roberts & Pitts 1997; Roberts *et al.* 1994). The second is the presence of large quantities of lithic artefacts, which for the most part are *in situ*, in addition to well preserved faunal remains (see Roberts & Parfitt 1999).

Initial work at Amey's Eartham Pit was carried out by Woodcock as part of his PhD thesis at Leicester University (Woodcock 1980, 1981). These early investigations produced around thirty-six handaxes, along with roughouts, cores and several hundred flakes (Woodcock 1981: 394). Woodcock (*ibid.*) also noted the fresh condition of the artefacts collected, which led him to suggest that they had remained *in situ* since they had been deposited by the hominins that had created them.

Full-scale excavation, in tandem with the gravel extraction process, was started between 1982 and 1983 under the direction of Mark Roberts (Pope 2002; Roberts 1986; Roberts & Parfitt 1999). The site was divided up into the two quarries present, designated Q1 and Q2 (Figure 4.7). Of these, Quarry 1 was subdivided into two further excavations, Q1/A and Q1/B. In addition, a series of geological test pits (GTP) were dug across the site. One of these test pits, GTP17 at Quarry 2, displays the remains of a horse butchery event accompanied by *in situ* reduction scatters representing approximately six to seven flint nodules (Roberts & Parfitt 1999: 372-8). One of these scatters is remarkable in that it shows the almost complete primary reduction sequence of a large globular nodule of flint (Refitting Group 49 in Pope 2002).

In summary, the work at Boxgrove, which continued until 1997, has presented Palaeolithic archaeologists with one of the best-preserved Middle Pleistocene landscapes within Europe, which harbours an extensive array of both *in situ* lithic artefacts and faunal materials (Wymer 1999: 148). The large number of handaxes present in primary context, in addition to the presence of substantial refitting sequences, makes Boxgrove a prime choice for incorporation into the study presented here.

Site context

The site of Boxgrove, situated ~12km north of the English Channel and 7km east of Chichester, presents a complete sequence of the West Sussex Coastal Plain deposits (Roberts & Parfitt 1999). It has been dated biostratigraphically through the presence of the water vole *Arvicola terrestris cantiana* and faunal remains known to have become extinct after the Anglian glaciation (Gamble 1999; Roberts & Parfitt 1999). This suggests that Boxgrove is dated to Interglacial IV of the Cromerian, which is correlated to MIS 13, and thus the site is taken to be around 500,000 years old (Figure 4.8). It is part of a group of archaeological sites that have been found along the Westbourne-Arundel Raised Beach, such as Slindon Park (Calkin 1934; Curwen 1925; Fowler 1932; Pope 2001; Woodcock 1978), Penfold's Pit (Jeffrey 1957; Woodcock 1981) and Manor Farm (Woodcock 1981), which have all produced Lower Palaeolithic material. This suggests that archaeology is preserved along the whole of the raised beach, though Boxgrove displays the highest degree of preservation out of all of these sites (Pope 2002).

A series of twelve straigraphical units make up the geological succession present at Boxgrove (Roberts & Parfitt 1999, see Table 4.3). These are comprised of a series of marine cycle deposits (Unit 3), overlain by the formation of lagoonal/esturine environments (Units 4a-d), which signal an increased presence of freshwater, before marsh conditions developed (Unit 5a-d). Brickearth deposits produced by increased runoff from the Downs followed (Unit 6), before the erosion of the chalk cliff face and talus slope (Units 7-8), as well as a series of gravel deposits (Units 9-11), covered the area (see Roberts & Parfitt 1999: Chapter 2). The majority of the lithic material excavated at the site comes from Units 4b and 4c. The former of these units appears to represent low energy deposition of silt and detrital chalky clays suspended in a body of water affected by diurnal/tidal activity. This is suggested to represent mudflats with water depths controlled by tides, although the absence of alluvial channelling may point to a body of water becoming enclosed from strong marine influences (MacPhail 1999). Unit 4c, on the other hand, represents the partially homogenised upper surface of the Slindon Silts, displaying pedogenesis of the sediments due to the lowering of the water table. This changed the landscape from a primarily marine zone to a more terrestrial ecosystem (*ibid.*). It is suggested that planting was supplied by the wooded environment beyond the nearby chalk cliff, which would have also aided in the introduction of animals to this area. Based on comparisons to other soil formations, such as IJsselmer, Holland, and Uxbridge, Middlesex, the formation of the Unit 4c soil horizon at Boxgrove is suggested to have occurred in as little as 20 years, with a suggested upper limit of 100 years, based on the effects of water table movements and weathering (*ibid.*). While some vertical movement of lithic artefacts can be shown within these layers, there is no evidence for extensive movement of lithic material by natural processes (Roberts & Parfitt 1999: Chapter 6). This suggests that the worked flints are in primary context, and many may be *in situ*.

The landscape context, therefore, appears to be an extended sequence, beginning with the presence of an open coastline represented by the Slindon Sands, which were laid down under nearshore, subtidal and intertidal conditions. This coastline was backed by a chalk cliff face, which was topped by woodland downs. The open coastline began to regress, as seen by the deposition of the Slindon Silts, indicating the move away from a more marine landscape to intertidal mudflats, though there is the suggestion that a more protected environment was present, such as a lagoon, as opposed to an open shoreface. Such a lagoon, if present, may have stretched as far as 30km west to east (Roberts & Parfitt 1999: 150). The archaeology becomes much more common during this period. The landscape then changes again to the more commonly held picture of Boxgrove, with the end of the marine influence and the development of the Unit 4c soil horizon, representing a major land surface with a grassy plain to the south of the chalk cliff face. The absence of bioturbation structures is attributed to either the increasing wetness of the soil, or a lack of trees and shrub-like plants being present within this landscape, which may be due to the presence of grazing herds. Following this, increasing wetness and flooding of the soil surface would have led to the marsh conditions seen in Unit 5a that preceded the deposition of the brickearth and the collapse of the cliff face. Hominins, therefore, were utilising the site under a range of climatic and environmental conditions, and the evidence of occupation seen within the archaeology indicates the exploitation of local raw material resources from the chalk cliff face for the production of lithic artefacts that were used in the butchery of large animals across the changing landscapes in front of the cliff (Holmes *et al.* 2010).

The material that will be analysed in this study originates from the excavation at the Q1/B 'waterhole' site. Here, the geological succession differs from that seen at the other excavated areas (Holmes *et al.* 2010; Roberts & Pope 2009). Unit 3 is overlain by a series of silt deposits produced by freshwater reworking of Units 4a and 4b, which are correlated with the formation of Unit 4c in the standard Boxgrove sequence (Figure 4.9). As yet, however, a suggested time frame for the deposition of the freshwater deposits at the waterhole site has not be put forward, though the correlation with Unit 4c is suggested to be chronostratigraphic, meaning that these sediments are taken to be laid down in the same 20-100 year time frame that has been suggested for the Unit 4c soil horizon discussed by MacPhail (1999). The ostracod record from this area indicates a series of shallow ponds that cut into and redeposited the marine deposits of the coastal plain, and which were fed by springs or groundwater (Holmes *et al.* 2010: 1520). The archaeology found throughout the freshwater deposits, in combination with evidence for the presence of butchered faunal remains, suggests that hominins used this locale as a semi-permanent source of fresh water, as well as a fixed hunting location within the Boxgrove landscape. Presence of game animals attracted to this water source is indicated by the high level of mineralised organic deposits attributed to dung, in addition to remains from natural deaths and the butchered carcasses remnants (*ibid*.: 1518). Unit 4u and 4 represent the main body of these freshwater sediments, and it is handaxes from the former of these units that comprise one half of the assemblage under investigation here. The second assemblage comes from the underlying freshwater scoured land surface of Unit 3/4. These were deemed to provide an appropriate and statistically significant sample, and it has been noted that these artefacts represent the products of hominins that have been deposited in primary context (pers. comm.. M. Roberts 7 June 2010). The 'waterhole' site and the handaxes examined are discussed in more detail below.

Excavation

The excavation of Boxgrove followed a rigorous methodology. The main excavated areas were established through test pitting and response to quarrying activity within the pit (Austin *et al.* 1999: 312). Test pitting revealed that the sediments of the Slindon Formation contained the majority of the lithic material, although faunal remains were found within the overlying Eartham Formation. The upper units were removed by machine down to the brickearth deposits of the latter Eartham Formation, which were then removed by hand – either by trowel, or by mattock where the deposits were thickest (Austin *et al.* 1999; Roberts 1986). The excavation area was then gridded into metre squares, or, where the archaeology was densest, down to $0.25m^2$, and controlled excavation in 5mm spits was carried out (Austin *et al.* 1999; Roberts 1986). All finds were recorded individually and lithic material over 20mm, along with faunal remains, were plotted in three dimensions, including orientation.

The method of excavation used at Boxgrove has enabled the geological sequence described in brief above to be established, and has also ensured that the material recovered was recorded as accurately as possible. Again, this means that the interpretation of the lithic material from Boxgrove as *in situ* is well founded and highlights its suitability for inclusion in the methodology discussed in this chapter.

The handaxes

Several hundred handaxes exist from the Boxgrove excavations. For the purpose of this study, 120 of these were analysed at the British Museum between June and September 2010. All of these handaxes were excavated from Quarry 1/B. Fifty of those studied were found within Unit 3/4 of the 'waterhole' site, whilst the remaining seventy handaxes were recovered from the overlying unit, Unit 4u. This accounts for the total number of handaxes excavated from each of these units, bar one ovate handaxe (#200), which is currently in the possession of Mark Roberts. All the handaxes studied are also considered to be in primary context.

Unit 3/4 is grouped together with Unit 3c and is described as the result of freshwater channels and freshwater scouring of the landsurface produced by springs originating at the chalk cliff base (Holmes *et al.* 2010; Roberts & Pope 2009). The unit is a member of the Slindon Sand and is made up of sand with some chalky clay deposits within. Outside of the main northwest-southeast channel that runs through the excavated area Unit 3 has undergone pedogenesis before the overlying units (4u and 4) were deposited. Lithic artefacts and faunal remains were found throughout Unit 3c and 3/4 and have been described as both reworked and *in situ* (Roberts & Pope 2009: 105). However, it is suggested that the majority of the handaxes were found in primary context, as water action was not strong enough to significantly move the larger artefacts present (pers. comm., M. Roberts 7 June 2010).

The handaxes from Unit 3/4 conform to the standard seen at Boxgrove, with the majority of tools being ovate in shape (Table 4.4). Of the fifty handaxes studied from this unit, 30% are classed as pointed using Roe's (1964, 1968) metrical analysis. However, these can generally be interpreted as cordates, which often grade into ovates, under the typological scheme suggested by Wymer (1968). Cordate and sub cordate types tend to predominate throughout this assemblage, followed by ovates. Two of the handaxes may also be classed as cleavers.

Unit 4u represents the basal unit of the pond sequence at Q1/B (Holmes *et al.* 2010: 1517). It is a massive silt unit formed from the reworking of Units 4a and 4b from the standard Boxgrove sequence. It has two associated units, 4u(s) and 4* (Holmes *et al.* 2010; Roberts & Pope 2009), the former of which represents sandier facies indicating high energy deposition. Unit 4u is also noted as the unit from which two incisors attributed to *Homo heidelbergensis* have been recovered (Holmes *et al.* 2010). Again, this unit contained a variety of lithic and faunal material that can be considered to be of primary context.

The handaxes from Unit 4u also conform to the Boxgrove standard (Table 4.5). Out of the seventy tools studied, 15.7% can be classed as pointed according to Roe's methodology. Again, these pointed forms are shown to be cordates and those that grade into ovates. Two of the handaxes are very small tools, which may be placed into Wymer's class E, though they appear more refined than examples that he presents. However, they are too thick to be placed with true ovates and, therefore, should not be classed with them. In contrast to the assemblage from Unit 3/4, there appears to be an even mixture of ovate and cordiform bifaces present throughout the Unit 4u assemblage, with few sub cordates and possibly two tools that may be classed as cleavers.

Both of the units studied have been analysed by Pope (2002), who has been able to assess the extent of artefact movement within the sediments and address the possibility of assemblage transformation by sedimentary and post depositional processes (as discussed by Schick 1992; Stern 1993, 1994). Pope notes that the distribution of artefacts within Unit 3/4 shows a high density of bifaces in the northwestern area of excavation, while Unit 4u displays a series of localised clusters that may indicate *in situ* scatters of material (see Figures 4.10 and 4.11). Refitting evidence from both units suggests that there has been a degree of reworking of material, which is supported by orientation analysis that displays preferred orientation along both a north-south and east-west axis. In addition the assemblages appear to have been winnowed, resulting in the movement of smaller lithic material. These results indicate that some concern over the integrity of the assemblages is necessary and suggests that aqueous re-arrangement may have had a direct affect on the lithic material excavated. However, Pope also noted that the bifaces recovered from Units 4u and those in contact with Unit 3 show little evidence for winnowing. This indicates that natural processes may only be exaggerating what are in fact the behavioural characteristics of the assemblages. Therefore, the majority of artefacts recovered from these units can be considered to be in primary context, if not *in situ*, and thus suitable for inclusion in this study.

The refitting material

Material has been refitted from all areas of the Boxgrove excavations (Austin *et al.* 1999). The refitting material analysed here comes from GTP17 in Quarry 2 (Table 4.6). This locality is also known as the 'horse butchery' site, due to the evidence of a single episode of hominin activity directly related to the butchery of a horse carcass that was secured either through hunting to confrontational scavenging. This event was preserved within Unit 4b. It has also produced an almost fully refitted round nodule, from which an ovate handaxe was removed (ibid.: 373). The ability to reconstruct a knapping sequence confirms that GTP17 is completely *in situ* and may even suggest that the lithic and faunal assemblage is contemporary at a time-scale that is more fine-grained than that provided by the geology (Pope 2002: 112).

A total of five refitting groups were analysed from the GTP17 material. All of these groups have previously been studied by Pope (2002) and have been used to demonstrate that the full range of biface production stages is present at GTP17. The flakes have been refitted through the use of adhesive, meaning that the refitting groups could not be deconstructed. This imposed problems in the interpretation of the sequences that varied according to their length. Larger groups tended to provide more difficulties, as flakes in the middle of the sequence were not fully visible. The majority of the sequences contain more than ten flakes. Only Group 4 contains fewer than ten flakes. Compared with the refitting material at Caddington (see below), the Boxgrove refits are more complete, though they also represent partial reduction sequences. The lack of complete sequences even in the true in situ series of flint scatters at GTP 17 serves to emphasis their rarity within the Palaeolithic record, and also highlights the complexity of their study in regards to tracing the individual knapper.

Caddington, Bedfordshire

Caddington is arguably another of the most famous sites in Britain (McNabb 2007: 206). In addition, it is another site that is considered to have produced *in situ* artefacts. Situated in the Chiltern Hills, near Luton, Caddington is part of a series of Acheulean sites (notably Round Green, Whipsnade and Gaddesden Row) found across fourteen working brickearth pits that were discovered by Worthington G. Smith (Sampson 1978b; Smith 1889, 1894, 1916). Following his move away from his Palaeolithic investigations at Stoke Newington (see Smith 1879, 1883b, 1884, 1887), Smith kept a careful eye on these sites and collected both implements and flake débitage from them, in addition to other artefacts, until his death in 1917. Smith regularly visited the Caddington brickearth pits (Figure 4.12), which form seven of the fourteen studied, from 1889 until approximately 1912, when the supply of finds from the site dried up (Sampson 1978b).

While Smith did a great service to future archaeologists by collecting as much material as possible from the brickearth pits at Caddington, even going so far as to train the work men to recognise worked flints (Smith 1904a; in White 1997: 912), his interpretation of the geology at the site was significantly flawed. However, recent excavation of the site (see Sampson 1978c), along with other geological surveys of the area (e.g. Avery *et al.* 1982), has provided a revaluation of the local geology, which allowed the site to be reinterpreted. In addition, Caddington, along with the other Chiltern sites, has proved difficult to date (McNabb 2007: 206). The geological deposits appear to bracket the implementiferous horizon between the Anglian and the early Devensian (Catt *et al.* 1978), while the Rackley site pollen analysis, the deposits of which have been correlated to those from the Cottages Site (Pit C) at Caddington, suggest an Eemian (MIS 5e) sequence (Campbell & Hubbard 1978). White (1997) has stated that the latter of these dates is doubtful, given the lack of evidence for hominins in Britain during this period, but maintains that the deposits indicate a late interglacial date. McNabb supports this notion and suggests a late MIS 9 date may be possible, although he does not deny that the site may be placed within the latter part of the Aveley/West Thurrock Interglacial (McNabb 2007: 207).

However, the dating and geological issues present at Caddington do not detract from the fact that this site presents evidence of hominin activity, including handaxe production, that is, in all likelihood, in primary context. The fact that many of the flakes that Smith collected from the site could be refitted emphasises this point. Therefore, its inclusion within this body of work is argued to be valid.

Site context

The village of Caddington, Bedfordshire, is situated ~4km west of Luton. It is approximately 190m above Ordinance Datum (hereafter OD) and located at the northeastern end of the Chiltern Hills. As mentioned previously, it is part of a larger series of Palaeolithic sites discovered by Worthington G. Smith, the closest of which is Whipsnade. The position of Caddington in relation to the other sites discussed is shown in Figure 4.6.

As noted above, although Smith took great care to record the geology at Caddington, his original interpretation of the deposits is demonstrably flawed. The *in situ* lithic artefacts from the site were found within the brickearth and a proposed 'second floor' was marked by heavily patinated white flints in the red brown sheet gravels above, while 'ocherous' artefacts were recovered from what Smith (1894) termed 'contorted drift'. Smith argued that the brickearth deposits had originally formed a continuous ancient land-surface, which he termed the 'Palaeolithic Floor', and this land-surface extended through to other sites within the Chilterns (Smith 1894, 1916). Therefore, the artefacts from all the localities could be considered contemporaneous.

Excavation of the Chiltern sites since Smiths investigations (e.g. Bridgland & Harding 1989; Sampson 1978c; White *et al.* 1999; Wymer 1980) have shown that this is not the case and that the brickearth is in fact a series of separate sedimentary accumulations that filled hollows within the underlying chalk, while the intervening land surface between these features has been removed by later slope activity (White 1997). As a result, Smith's idea of a continuous living floor across the Chiltern Hills must be refuted. In addition, Bradley and Sampson (1978) have shown that the proposed 'second floor' at

Caddington is erroneous and that the white patinated lithics are likely to be from the brickearth.

The geology of Caddington has been discussed extensively by both Campbell and Sampson (1978), as well as White (1997). Therefore, only a brief summary will be presented here. This will based up on the correlation of Smith's (Smith 1894) description of the strata at The Cottages Site (Pit C) with that of the Rackley site (Campbell & Sampson 1978; Sampson 1978a). This correlation is presented in Table 4.7, while the sections from the Rackley Site and Smith's investigations are seen in Figures 4.13 and 4.14 respectively. The base of the sequence is represented by the lower part of the Upper Chalk, although Smith never reached this at Pit C, and this is overlain with *in situ* Clay-with-flints in parts along with Loveday's (1962) Plateau Drift type (b). At the southwest of the Rackley site there is a yellow silty clay deposit, which also cannot be correlated to Pit C. The fossil horizon at the Rackley site, a gravel deposit within a silty clay matrix, is correlated with the brickearth from below the 'Palaeolithic Floor' (H), though Smith found no fossils during his excavations, excepting the mention of horse teeth extracted from Pit C in 1892, though these were said to have "fell into pieces and blown away" (Smith 1894: 166-7). Given that the fossils within the strata at the Rackley Site are in exceptionally poor condition, it is possible that what Smith wrote is correct and this is the reason for the lack of fossil finds within the Caddington deposits.

Overlaying the fossil horizon is a lens of grey mottled silty clay restricted to the southwest of the Rackley site. Again, this layer has no correlate in Smith's geology at Pit C. However, the sediment filling the chalk doline at the Rackley site has been attributed to Barrow's (1919) True Brickearth and also to the brickearth deposits and 'Palaeolithic Floor' at Pit C (F and G). This is overlain by subangular flint gravels, which are correlated to Smith's Red Brown Sheet Gravels (E). This is superseded by another clay layer, attributed to Smith's Grey White Clay (D), and followed with the ferruginous gravels that make up the 'contorted drift' (C), which exhibits intense periglacial conditions (Sampson 1978a). Partially reworked Devensian loess, Smith's Red Brown Drift Clay or Loam (B), and finally Topsoil finish the sequence.

The palaeoecological assessment of the site by Sampson (1978c) and others has allowed for an interpretation of the landscape in which hominins would have acted (see Catt *et al.* 1978), which is recounted here. The site at Caddington appears to represent a marsh or small lake surrounded by grassland, with dense forest environment close by. Given the modern local variation in the calciferous nature of the soil, it may also have provided a diversity of plant life growing in close proximity, though it is not clear whether this would have been the case in the Pleistocene. The source of fresh water and the grazing provided by the surrounding environment would have been highly attractive to game species, which in turn would have been a primary draw for hominins active in the region. Knapping by such hominins took place on an irregular ground surface with an incline in an east/northeast direction. The distance between this activity and the lake edge is currently unknown. Two separate episodes of knapping can be determined, though microstratigraphic details are lacking which would allow any temporal correlation to be determined. No refitting flakes link the two clusters, suggesting some temporal displacement, though this may have been as little as a few days or weeks. Artefacts were produced using four different types of flint, all of which can be found within the surrounding clay-with-flints, and though the precise raw material source has not been ascertained, it is assumed that raw materials for tool manufacture could have been accessed through erosion processes.

Primarily, it is the brickearth deposits and the 'contorted drift' that are of interest, as the artefacts recovered from Caddington were found in these strata. The 'contorted drift' exhibits common cryoturbation features and patches of clay and brickearth represent reworking by frost heaving (Sampson 1978a). The material found within this stratum is obviously derived, a fact that was well recognised by Smith (1894), though the exact origin of the gravels is currently unknown. On the other hand, the brickearth deposits are attributed to erosion of older loess deposits that were mixed with clays that were probably derived from the Plateau Drift (Catt 1978). Samples taken from the Rackley deposits suggest a uniform deposition and the sediment is homogeneous (Sampson 1978a). Therefore, if the correlation with

Smith's 'Palaeolithic Floor' is correct, the description of the artefacts from this stratum as *in situ* is likely to be correct. It is important to note that the brickearth does not have a suggested time frame for its deposition, although the hominin activity at the site is suggested to have taken place over a short period within an open environment (White 1997: 918). This interpretation of the geological strata in which the artefacts were found will have important implications for how the lithic material will be analysed within this study.

Excavation

Although no formal excavations were ever undertaken at Caddington, Smith supervised some work there and is known to have trained the workmen to recognise worked flint, as evidenced by his leaflet discussing the finds from Stoke Newington, which states that some of the finds were "found by men specially set on to search for stone weapons by MR W.G. SMITH" (O'Conner 2007: 90). Smith's excavations at The Cottages Site have also been detailed by Campbell and Sampson (1978), which show how he worked alongside the excavation of the brickearth. In addition, he took care to record details of the finds that he made and produced section drawings of the sites, although no three dimensional coordinates were used (White 1997), unlike at the other sites discussed. Also photographic records survive, which Smith compiled with the aid of his son (Roe 2009: 92).

Smith was also an advocate of collecting all available material, rather than just the classic implements, stating that focusing on such artefacts distorted the perception of the past (O'Conner 2007: 89; Smith 1879, 1883a). Smith also had experience with forgeries of Palaeolithic implements (Smith 1894: 294-8), a great problem at the time. Sampson (1978b) has already noted that Smith's experience, alongside the fact that he recorded no suspicions of the Caddington material and that the lithics do not resemble the black sheen of freshly flaked flint found in the locality. Therefore, it appears unreasonable to refute any of the Caddington assemblage as being faked.

The result of Smith's care and attention to the recovery of lithic material from Caddington emphasises that it can be included within this research project. In addition, it is certain that the artefacts studied are of Palaeolithic origin, and are free from forgeries, especially given that Smith himself found many of the handaxes and flakes studied.

The handaxes

A total of 66 handaxes were studied at the British Museum in June 2010. These come from the various brickearth pits that Smith excavated and collected material from. Although it is not possible to ascribe every implement to the pit in which it was found (Roe 1981: 197), an effort has been made to provenance each handaxe studied using Smith's (n.d.) 'List of Palaeolithic implements' (hereafter LPI) (see Table 4.8). It should also be noted that some of the handaxes come from the 'Palaeolithic Floor' brickearth, while the remainder are from the 'contorted drift'. Five of the artefacts studied were listed as 'no fixed provenance' (NFP), which indicated artefacts known to come from Caddington, but which cannot be traced back to a specific pit. Two of these handaxes still had Smith's find numbers on (WGS 1393 and 1387) and are attributed to the initial finds from behind Dunstable Grammar School (Smith 1889; 1894: 93; n.d.). According to the record in '*Man the Primeval Savage*' gravels were sent to Dunstable from both Pit B and C at Caddington (Smith 1894: 94). However, it is impossible to accurately attribute these to these pits, nor determine whether they originated from the Palaeolithic Floor or Contorted Drift. Therefore, no attempt was made to associate them to a specific find spot and they, along with the other unprovinanced artefacts, were not included in the analyses presented in this study.

The handaxes present a combination of ovate and pointed forms, and have been grouped into Roe's Group VII, though he noted an anomalous presence of acutely pointed artefacts and evidence of Levallois cores (Roe 1981: 191), which are of the simple prepared type described by White and Ashton (2003). If White (1997) is correct in arguing that Caddington was active during the end of an interglacial period, this may add support to McNabb's (2007) suggestion of an MIS 9 date, though this is the earliest it could be, given that no Levallois has been found earlier than the end of this interglacial in Britain (*ibid.*: Chapter 6).

However, the main issue is how to produce an accurate study as regards the individual from the material available at Caddington. In answer to this, the artefacts were divided according to the brickearth pits from which they were recovered. As the evidence above shows, the majority of sites from the Chiltern Hills are formed in solution hollows in the underlying chalk. Therefore, it is possible that the pits Smith studied are in fact separate instances of Palaeolithic activity, possibly the results of varied groups of hominins spanning multiple generations of activity throughout the time period that the deposits were lain down. It therefore appears appropriate to acknowledge this through the course of this study, especially when the aim is to produce fine-grained analysis of the artefacts. In addition, artefacts from the Pit C assemblage were split into those from the brickearth and 'contorted drift' using information from the British Museum catalogue. Contextual information for artefacts from the other pits that Smith investigated is predominately lacking. Therefore, Pit C will be analysed as a separate assemblage throughout this thesis in order to investigate differences between the Palaeolithic Floor and Contorted Drift material, as well as being included in the analysis of the combined Caddington assemblage (Table 4.9).

The refitting material

Along with recovering implements and flakes from the Caddington brickearth pits, Worthington Smith also refitted many flakes and broken artefacts using shellac dissolved in spirit (Smith 1894: 127), apparently influenced by Spurrell's (1880a, b) refitting at Crayford. Like the refitting material from Boxgrove, the flakes could not be separated. All the refitting material studied from Caddington can be attributed to Smith's work at the Cottages Site (Pit C), apart from two sets of refits, which are listed as no fixed provenance (NFP in Table 4.10). Of these two sets of refits, one is of only two flakes and will not be discussed further. The other is listed as possibly originating from Pit C and, thus, will be included with the rest of the material studied.

The majority of the refitting material consists of few flakes, with only four of the sequences having ten or more flakes. In addition, many of the sequences are missing intermediate flakes and it must be stressed that these are often not complete. This has obvious implications for the interpretation of this material, which will be addressed in Chapter Six. However, all of the material studies comes from the 'Palaeolithic Floor' and, therefore, can be considered to be of primary context, if not *in situ*.

Foxhall Road, Ipswich

Foxhall Road (also referred to as Derby Road or the Valley Brickfield) represents one of the more under appreciated Palaeolithic sites found in Britain. It was originally located in a brick-earth pit south of Foxhall Road and situated on a gravel plateau at a height of ~40m (135 ft) above OD (White & Plunkett 2004; Wymer 1985, 1999). The site was discovered by Nina Layard after a "large early Palaeolithic hatchet in Levington Road" came into her possession in 1901 (Layard 1903). Foxhall Road was subsequently excavated over two seasons, in the winters of 1903-4 (Layard 1904) and 1904-5 (Layard 1906a, b), which unearthed an estimated 400 to 500 artefacts (White & Plunkett 2004: 77). Further excavation work was undertaken by Reginald Smith and Nina Layard in 1914 (Smith 1921b), after the brick-earth pit was built over, and again in 1921 by James Reid Moir (Boswell & Reid Moir 1923). These later studies served to mark Foxhall Road as a key site in the establishment of a standardised geological sequence in the 1920s (O'Conner 2007).

Following these initial excavations, Foxhall Road received little attention outside of summaries of the artefacts (see Roe 1981; Wymer 1985) and attempts to locate any extension of the implementiferous deposits have failed (Wymer 1985: 220). However, the site has recently reclaimed its rightful place amongst other Lower Palaeolithic sites in Britain thanks to the re-examination by White and Plunkett (2004). This work has provided a reappraisal of the site's geology and stratigraphy, based on Nina Layard's original notes, and has shown that the Acheulean assemblage, which had previously been treated as homogeneous (e.g. Roe 1968, 1981; White 1998a; Wymer 1985), is in fact the product of two events that are separated by a short period of time. This knowledge, coupled with the fact that many of the artefacts were found *in situ* and several have been suggested to be the work of the same hand (Layard

1904; White & Plunkett 2004), enables the Foxhall Road assemblages to be incorporated into the analysis presented in this thesis.

Site context

The site of Foxhall Road is an erstwhile gravel and brickpit situated on the east side of Ipswich (Figure 4.15). Its location in respect to the other sites discussed is shown in Figure 4.6. The site lies within a slight depression that coincides with a narrow strip of brickearth. The 200m wide hollow that the deposits occupy has been interpreted as both a silted up river (Smith 1921b) and the result of a lacustrine environment (Boswell & Reid Moir 1923). However, White and Plunkett's (2004: 73-5) recent reanalysis suggests that both of these interpretations may be correct. The following brief description of the site context is formed from their account.

The site is made up of a complex series of interglacial deposits overlying Anglian Till (Figure 4.16). The basal deposits are attributed to the late Anglian and early Hoxnian and are glacio-fluvial and colluvial in nature. The lowermost sediments excavated were made up of variable sand and coarse gravel deposits with a high fossiliferous component, which was termed the 'bone bed'. Following this, the interglacial deposits were emplaced through solifluction, slopewash and aeolian processes. The site is suggested to represent a small lake at this stage, connected to a system of similar features by a feeder system. The archaeological evidence recovered from the site (below) supports the notion of low sedimentation rates and fluctuations in water level. Following this phase, high-energy fluvial sands and gravels were deposited. These were possibly laid down in cooler climatic conditions and are taken to indicate the integration of the site into a wider drainage system, suggesting the presence of a river. The overall sequence is said to be typical of the Hoxnian interglacial within East Anglia and it has been suggested that the site can be assigned to MIS 11 (White & Plunkett 2004; Wymer 1999). This is supported by the lack of evidence for prepared core technique, which is generally held to occur from early MIS 8 in Britain (Bridgland 1994; White & Ashton 2003).

Archaeological material primarily comes from the grey clay and red gravel layers within the stratigraphic sequence. The grey clay presents a continuous deposit with a maximum thickness of ~0.9m, showing some variation through out. It is described as being compact and devoid of stones, sandy and also gravelly, which may relate to admixture with the deposits that overlay it. The grey clay deposits are attributed to a lacustrine environment. Handaxes from this layer are described below, but are primarily ovate in shape and appear to have been introduced to the site form elsewhere. The later red gravel layer, on the other hand, was a flint rich deposit that afforded a raw material source that appears to have been readily utilised by the hominins active at the site. It extends in thickness from around 0.45m to only a few millimetres and is described as being horizontally bedded and probably lain down under water activity. The differences between these two deposits highlights the fact that the Foxhall Road assemblage is likely to be two separate accumulations resulting from two temporally spaced periods of hominin activity, something that is supported by the analysis of the artefacts themselves (see below). However, specific time depths for either deposit have not been suggested, though activity at the site is interpreted as having taken place during an interglacial period (White & Plunkett 2004). The landscape setting for the site at Foxhall Road then presents the picture of an important place for Middle Pleistocene hominins, providing a number of resources including access to fresh water (from at different times a lake or river), plants for food, prey species (evidenced by fossils from the bone bed), shelter and, at least while the red gravel was present, a raw material source. The hominin activity seen appears to have been localised to the area surrounding the site, with only evidence of handaxes transported from elsewhere indicating evidence of a wider network of movements through the landscape.

The almost full Hoxnian sequence at Foxhall Road has also drawn parallels to the geology of other Palaeolithic sites, namely Hoxne itself, Elveden, Marks Tey and Copford (Roe 1981; White & Plunkett 2004). In addition, there are several sites that are also found in similar depressions within the Anglian Till, such as West Stow (Gowlett & Hallos 2000; Preece *et al.* 2000; Preece *et al.* 1991), Hatfield (Sparks *et al.* 1969), Barnham (Ashton *et al.* 1998), Hoxne (Singer *et al.* 1993; West 1956), Elveden (Ashton *et al.* 2000), and Marks Tey

(Turner 1970), which also display evidence of infill from lacustrine and fluvial sources that is also dated to MSI 11 (White & Plunkett 2004). The evidence from these sites, therefore, supports the general interpretation of the Foxhall Road sequence.

Excavation

Although excavated in the very early 1900s, Miss Layard's excavation at Foxhall Road made sure to record as much information as possible. Written records were kept for each artefact that was found and, more importantly, Miss Layard did not concentrate solely upon the classic tool forms, but chose to collect every piece of flint that showed human modification (White & Plunkett 2004: 41). However, during the first season of excavation, only the presence of flakes was noted, without reference to quantities or recording them in detail. Still, Miss Layard's notes include find dates, artefact types, find depths and stratigraphic contexts for all the artefacts recovered. Also present from the 1903-4 season are a ground plan, showing the locations of most finds, in addition to section and stratigraphic drawings and a photograph of what White and Plunkett hold to be the west face of the excavation.

The second season continued in a similar manner, although now Miss Layard began to record grid coordinates for each find, as well as recording and marking all excavated flakes. The grid coordinates, however, are not especially useful, as there is no available ground plan with which to associate them. This means that White and Plunkett have only been able to reconstruct the distribution of artefacts from the 1904-5 excavations to within one yard, producing a less robust picture of the spread of lithic material. Again, several graphical representations of the excavation are also surviving.

In short, the excavation methods used present extraordinary diligence on the part of Miss Layard, which has aided in White and Plunkett's recent revaluation of Foxhall Road. It also adds credence to their suggestion and supports the fact that the Foxhall Road handaxes are of primary context, if not *in situ* (see below).

The handaxes

Out of all the artefacts recovered from the Foxhall Road excavations, approximately 134 handaxes were recorded (Wymer 1999: 162). However, only 97 remain extant within museum collections (White & Plunkett 2004). Of these, twenty are attributed to Nina Layard's initial investigation of the site in 1902 and have no firm contextual information available. Forty-three are the product of Nina Layard's 1903-1905 excavations, while the remainder were discovered by Miss Layard and Smith (four) in 1914 and Reid Moir in 1921 (30). For the purposes of this study, I have focused on the finds collected by Nina Layard, which were examined at Ipswich Museum in the summer of 2010. All of the available handaxes were examined. However, it should be noted that four of the forty-three handaxes from Miss Layard's excavations are not present in the Ipswich collections (numbers 34, 45, 102 and 176, see White & Plunkett 2004: Table A2.1). In addition, handaxe number 33 could not be analysed using the methods described here, as this artefact is still embedded in a block of matrix removed during the 1903-4 excavations.

Not including those handaxes from the initial investigations of 1902, the majority of the artefacts examined (32) can be attributed to either the red gravel or grey clay layers (see Table 4.11). The remaining six come from the red and grey clay, white gravelly clay and white sandy gravel, as well as the upper horizontal beds. Of these, both the horizontal beds and the white gravelly clay are considered to be either mixed or derived, while the other layers are limited in the numbers of archaeological finds. Therefore, it appears that only the red gravel and grey clay are archaeologically meaningful (White & Plunkett 2004: 91), indicating two separate hominin exploitation events, which had previously been suggested by both Roe (1981: 178) and Wymer (1985: 224). It is the artefacts from these that will be focus of this inquiry into the Foxhall Road assemblages.

The grey clay is interpreted as being formed under low energy conditions, such as still, or very slow flowing water. Miss Layard indicates that there were no unworked pebbles amongst the artefacts found, suggesting that the artefacts were not moved by fluvial activity and are, more or less, in situ (Layard 1904). This is supported by White and Plunkett's (2004) orientation studies, which do not suggest the artefacts were aligned by natural causes, though this analysis was based on the assumption that Miss Layard's excavation notes provide accurate details pertaining to artefact orientation. The assemblage presents a total of nineteen handaxes, of which fourteen are ovate and five are pointed. Sixteen of these handaxes were available for study (see Table 4.12). No knapping débitage is present within the grey clay, which seems to indicate that the handaxes were manufactured elsewhere before being brought to the site and discarded (ibid.: 150). In addition, and most importantly of all in terms of this study, several of the handaxes found within the grey clay have been suggested to indicate idiosyncratic features that could possibly indicate their individual creators (Layard 1904; White & Plunkett 2004).

The red gravel is the richest archaeological horizon at Foxhall Road (Wymer 1985: 224). It is probably a slope deposit, yet the artefacts within and atop it appear relatively fresh, indicating a low degree of disturbance (White & Plunkett 2004: 91). However, orientation studies show that the assemblage has been moved to some extent, although this does not detract from the artefacts being considered in primary context. Edge damage is attributed to possible trampling of artefacts on the gravel surface and post-depositional factors. The presence of roughouts and flakes from both hard and soft hammer techniques suggests that handaxe manufacture may have been taking place (ibid.: 150). Seventeen handaxes were recovered from this horizon, of which sixteen were available for study within Ipswich Museum (see Table 4.13). In contrast to the assemblage from the grey clay, small pointed forms dominate the handaxes from the red gravel. Only five are ovate, with one other biface described as a cleaver. However, two of the ovate handaxes (106b and 157b) may be derived from the grey clay that lies beneath (ibid.: 119). Similarly, handaxe 132b, found in the white sandy gravel, may also be derived from the grey clay. The possibility that these artefacts are part of the grey clay assemblage will be explored during the course of the analyses presented in this volume.

All the artefacts from Foxhall Road are made using flint as a raw material (White & Plunkett 2004: 93). However, the exact source of flint cannot currently be ascertained, though microscopic analysis has shown that several types can be identified. The predominance of worn cortex amongst the artefacts suggests that the majority of flint was sourced from gravels, rather than a chalk outcrop. Therefore, the majority of flint used was from secondary sources, thought this does not preclude the contribution of fresh flint (ibid.: 94).

HOMININ LANDSCAPES AND ISSUES OF TIME AVERAGING

The three sites selected for study in this thesis display some common features that can be linked to landscape use by hominins in the Lower Palaeolithic. Some of these behavioural traits have been mentioned already in Chapter Two, but will be reiterated here.

Firstly, all three of the archaeological sites display evidence for the local mature of life within the Lower Palaeolithic. The artefacts recovered display the use of localised raw materials; from the chalk cliff face at Boxgrove, to the flint nodules eroded out of the clay-with-flints at Caddington and the freely available flint gravels at Foxhall Road. Only the latter of these sites displays any evidence for the extended movement of tools into the site, with the finely worked ovate handaxes seen in the grey clay at Foxhall Road. However, these appear to have been discarded once used and show no evidence for further curation. The sites also have a common theme in that they all display evidence for hominins being attracted to fresh water sources, which would have afforded additional resources in the form of game animals, as evidenced by faunal remains. It is probably that these sites formed part of a 'local hominin network' along with similar locales, suggesting that hominins moved between important sources of resources as necessary and in response to changes in the environment (Gamble 1996a, b). Such sites, therefore, would have been key nodes in such a localised network, where fundamental activities to hominin live were enacted (White & Plunkett 2004). This leads them to be understood as 'landscapes of habit', places that would have been frequently visited by hominins and embedded in routine practices that took place in and around familiar settings, which in turn shaped their social life (Gamble 1999; Gosden 1994).

However, the fact that such sites represent areas that were repeatedly visited presents an issue when considering the possibilities of tracing individual hominins within the Lower Palaeolithic archaeological record. As Stern (1993, 1994) has already discussed, much of Palaeolithic archaeology is built up from palimpsests of activity, making it difficult for inter-site comparisons to be produced. However, this is not the goal of the analysis presented here. Yet it is still important to consider issues of time depth, given that the deposition of the artefacts at the three archaeological sites discussed above cannot be mapped in terms of its specific chronological extent. Only Boxgrove provides some notion of an explicit time frame with the suggestion that the pedogenesis of Unit 4c may have taken place over 20-100 years. The altered stratigraphic sequence from the waterhole site, where the artefacts under study originate from, is attributed to a similar time frame, though it cannot be said with any certainty how long it too the individual layers of deposits to be laid down. As a result, it is impossible to tell whether the handaxes from both Unit 3/4 and 4u are a result of one period of activity or multiple visits, although it is safe to assume that such visits would have occurred over a constrained period of time. At the lower end of MacPhail's (1999) time scale, we would almost certainly be seeing actions from a single generation of hominins across multiple visits, though at the higher end we may be looking at the activities of several generations being present. In terms of the divisions at the waterhole site, this means that the artefacts may be the result of a single generation's repeated visits, or multiple aggregations by different groups. Refitting sequence from GTP17, on the other hand, presents more temporally constrained evidence of knapping by individual hominins, perhaps over the same brief period of activity.

At both Foxhall Road and Caddington there is currently no suggested time frame for the deposition of the recovered artefacts, other than the stratigraphic features that they were found in and their attribution to broader geochronological periods. However, clustering of artefacts within the material record from both sites does suggest evidence of at least some temporally constrained activities. Catt *et al*. (1978) have described two separate knapping episodes from the Pit C site at Caddington, though Smith's records lack the microstratigraphic evidence needed to determine whether these took place at the same or different periods of time. Refitting sequences from the Pit C site also provide evidence of temporally constrained activities taking place. Foxhall Road also displays evidence for localised clusters of tools, the tools from which are attributed to concurrent periods of activity. Both also display evidence for multiple occupancies of the sites, with Foxhall Road having evidence of two temporally distinct phases of activity within the grey clay and red gravels, in addition to other temporally displaced deposits of artefacts throughout some of the other layers, while Caddington presents artefactual evidence from the Palaeolithic Floor stratum and the overlying and almost definitely derived Contorted Drift. In addition, the Caddington site complex presents a number of brickearth pits, none of which can be considered temporally linked. As a result, the analysis of these sites will be approached though both combined analysis and division of the assemblages into subgroups as discussed above.

Despite these issues in ascertaining precise time depths for the sites under study, all of the sites do display evidence of occupational contemporanity, as discussed by Conard and Adler (Conard & Adler 1997). The evidence from lithic scatters and refitting material indicate at least some of the activities are occupationally contemporaneous. In combination with the fact that the artefacts can reasonably be considered as *in situ*, these sites are arguably suitable for an analysis of the individual. In addition, given that the aim of the analysis is to trace individuals through their idiosyncratic actions, if successful the results may be able to highlight whether the activities presented by the archaeological material can be considered contemporaneous or not. However, it is important to consider time depth during the interpretation of the analysis, as artefacts shown to cluster from temporally distinct sets of actions may serve to highlight how tool forms can be re-made by different individuals at different times.

SUMMARY

This chapter has provided the reasoning behind the selection of the Acheulean handaxe as the focus for the methodologies that will be addressed over the course of this thesis. Additionally, the implications for the selection of this particular tool type and the need for a control to test the methods selected have been highlighted. This led to the production of an assemblage of replica tools by a number of modern knappers so that the links between tools and their creators were known. Finally, the sites of Boxgrove, Foxhall Road and Caddington have been discussed in detail, along with their landscape settings and the how this relates to hominin behaviour. Their suitability for inclusion in this study has been emphasised by the presence of relatively sound stratigraphic integrity and *in situ* stone tools. However, it is important to note that issues in assessing the time depth of often plague analysis of Palaeolithic sites, and although those discussed here present some of the better preserved examples, there are still difficulties in understanding whether the activities represented at these locales are the results of brief phases of hominin activity, or multigenerational accumulations of material.

CHAPTER FIVE
A MORPHOMETRIC ASSESSMENT OF THE REPLICA ASSEMBLAGE

INTRODUCTION

A series of new and innovative techniques with the potential for analysing knapping idiosyncrasies have been discussed in Chapter Three. However, it is impossible to ignore those methods that have already been applied to the analysis of lithic artefacts. One such technique has been the metrical analysis of stone tools, which has been used in the discussion of topics such as variation in shape (Wynn & Tierson 1990), as well as used heavily in typological assessments of stone tools (for example Bordes 1961; and Roe 1964; 1968, 1981). Given that knapping flint inherently modifies the shape of the raw material in order to produce the final form of the tool, it was deemed prudent to explore the possibilities of using conventional metrical analysis to trace idiosyncrasies in lithic artefacts. Therefore, the twenty-six tools produced for the replica assemblage were subjected to quantitative typological analysis using both Bordes' and Roe's methods, as well as Wymer's (1968, 1985) qualitative analysis for comparison. A two-dimensional morphometric analysis of the edge and overall shape of the tools was also carried out, using a method similar to that applied by Wynn and Tierson (1990).

The possibility of assessing the similarity of the tools using nothing but the naked eye and the viewer's best judgement was also explored. The reason for attempting this was to allow the methods discussed in Chapter Three to be compared to a purely subjective analysis of the handaxes from the replica assemblage. Furthermore, it should be noted that, no matter the technological advances made in the analysis of handaxes, the only method of identifying and discriminating between such tools available to hominins was based on visual recognition and as such, idiosyncratic similarities and differences will always be in the eye of the beholder. Therefore, the handaxes were grouped using a visual comparison of their shape, scar patterns, and evidence of skilled manufacture. The results of this analysis will be discussed first, followed by the typological and morphometric analyses in order for a comparison of these methods to take place.

A VISUAL ASSESSMENT

All twenty-six handaxes from the replica assemblage were analysed for the visual assessment. The analysis undertaken was purely qualitative and aimed to group the tools according to traits that may be representative of the knapper involved in their production. To this end, the handaxes were grouped using attributes such as their outline shape, tip and butt shape, flake scar pattern and, to a lesser extent, the size of the tool. A total of six groups were suggested, which will be discussed in detail below. These groups represent the arbitrary selection of tools based upon a subjective assessment of whether they were considered to be sufficiently similar to have been made by the same person. In addition, while six groups of handaxes were defined, it should be noted that when the analysis took place the total number of knappers involved in the production of the replica assemblage was unknown due to the blind test conditions instigated as part of the analysis. As a result, the groups correspond to no predefined classification system, but rather to the viewer's 'gut feelings' or 'eye-balling' of relationships between the artefacts. Similar subjective methods for analysing handaxes have been proposed, for example McNabb *et al.*'s (2004) technique for assessing symmetry. Such methods have been criticised for not employing an objective analysis of the data (e.g. Mithen & Machin 2004). However, for the purpose of this analysis, the aim of the subjective assessment discussed below was to determine whether a simple visual analysis of the replica assemblage was capable of grouping tools manufacture by the same individual to the same degree as the other quantitative methods discussed in this thesis.

Group 1

The first group to be defined contains handaxe number 1, 2, 5, 8, 15, 20, 21 and 24 (Figure 5.1). All of the tools in this group are ovate in shape with rounded tips. Handaxes 1, 5 and 24 appear to display narrowing towards the tips and show a smaller maximum width in comparison to the other tools within the group. Handaxe number 8, whilst much smaller than the rest of the group, has a very similar outline shape.

Group 2

This second group contains handaxe numbers 13, 22 and 25 (Figure 5.2). All of these tools are small and ovate in shape, though number 22 may also be classed as a pointed form due to the way the edges narrow towards the tip. Number 25 is a twisted ovate, displaying a Z-shaped profile, which may provide an indication of handedness, though this may also be a result of particular knapping techniques or resharpening (White 1998b). Number 13 is relatively well-worked, though there is a cortical element remaining on one side and it also displays a shouldered butt. Finally, number 22 appears to have been produced using a much lower quality raw material, but also displays a shouldered butt and evidence of working that appears to retain a semblance of symmetry.

Group 3

Group three contains four handaxes; numbers 4, 10, 12 and 18 (Figure 5.3). The point of maximum width for all of these tools appears to be relatively central, occurring around the midpoint of the maximum length of the tools. All four handaxes appear elongated and ovate in shape.

Group 4

This group contains handaxes 17 and 19 (Figure 5.4). These tools contrast sharply with the other tools present in the assemblage, but are very similar to each other in appearance. The butts of the tools appear shouldered and both retain some cortex on one face near to the butt. The tips are pointed and display relatively similar curvature and, although handaxe 19 is larger and wider, the overall outline shape is very similar. Finally, these tools display an almost identical level of thinning applied within the final stage of reduction.

Group 5

Handaxe number 9, 14, 16 and 23 were assigned to group five (Figure 5.5). All of the tools within this group are pointed, with general highly pointed tips. However, handaxe 14 displays a much more rounder tip. All of the tools have wide, almost flat butts, although numbers 9 and 16 display some curvature. They are also all thick in profile.

Group 6

The final group consists of handaxes 3, 6, 7, 11 and 26 (Figure 5.6). All of these tools are very triangular in shape. The width of the tools is very thin towards the tip, which is usually rounded, although the tip of handaxe 11 appears missing, possibly due to a final thinning flake removal or resharpening. All of the handaxes have cortical butts, bar number 11, which has a chalk inclusion in the middle of one face that may represent some remaining cortex that was not removed.

After dividing the handaxes into the above groups, the accuracy of this visual analysis was tested by comparing the results with the information regarding each tools creator, which had remained secret as per the blind test condition discussed in Chapter Three. As Table 5.1 shows, the visual analysis was unable to accurately separate the tools according to who had knapped them and, thus, is an inappropriate method for attempts to trace tools back to their knapper. However, it should be noted that in the majority of the groups the products of a single knapper make up more than half of the tools present. For example, Group 1 contains a total of eight handaxes, with Knapper 1 creating five of these tools. Group 4, which contains the highly comparable handaxes 17 and 19, also correctly linked the products of a single knapper. Therefore, though the visual analysis is unsuccessful at producing an accurate separation of stone tools according to their creators, it appears that a visual assessment is considered to have a remarkable ability to group some tools produced by same knapper. This displays the human eye's ability to qualitatively group objects based on visually assessed similarities with some level of accuracy, a point which may be important when the capacity for archaic hominins to differentiate between tools created by different individuals is considered. However, it is possible that these results are caused by a sampling bias, especially given that two of the knappers involved only contributed a single tool each. As a result, further testing using visual analysis in combination with a more robust assemblage may be required to truly determine the effectiveness of this technique.

A TYPOLOGICAL ASSESSMENT

A typological assessment of the twenty-six replica handaxes was undertaken, using the quantitative techniques outlined by Bordes (1961) and Roe (1968). Measurements for each of the handaxes were produced according to the published protocol for each of these methodologies. In addition, a qualitative typological analysis, as suggested by Wymer, was conducted to provide a comparison. Each of the methods was then compared to the known identities of the individuals involved in the production of the replica assemblage. Using this comparison, the ability to accurately differentiate between knappers was tested for each of the typologies discussed.

Bordes' Typology

Bordes' technique involves measuring the maximum length and width of each tool, in addition to the distance from the butt to the point of maximum width and the width at the midpoint (see Figure 5.7). The edge convergence and relative location of the maximum width can then be calculated as follows:

- The relative location of maximum width is calculated by dividing the maximum length by the distance to the maximum width of the tool.
- The edge convergence is calculated by dividing the width at the midpoint by the maximum width.

The values produced for each handaxe are plotted as a scatter diagram, which is arbitrarily divided into four distinct zones. Where the tools fall within these zones serves to defined the class of handaxe, whether that be triangular (Zone I), subtriangular (Zone II), cordiform (Zone III), or discoidal, ovate or limande (Zone IV) (Debénath & Dibble 1994: 132). The results of the typological assessment of the replica assemblage according to Bordes' typology is given in Table 5.2 and are provided as a scatter diagram (see Figure 5.8).

Out of the replica assemblage, only one replica handaxe is classified as triangular in shape (number 6). Handaxe number 23 and 3 are classified as subtriangular, though they are very different in shape, with handaxe 3 appearing similar in shape to number 6. The separation between these tools is due to a much higher location of maximum width value and a lower edge convergence in handaxe 6, though this does not appear visible to the naked eye.

The next class to be considered is that of the cordiforms, which is similar to Wymer's class J discussed below (McPherron 1994: 91). This includes handaxes 9, 11, 17, 19, 24 and 26. However, handaxe number 26 appears more suited to the triangular or subtriangular class. Numbers 9 and 16, on the other hand, appear similar to 23, though 9 is more rounded. Handaxes 11 and 17 cluster closely together, due to comparable location of maximum width and edge convergence values. However, visual analysis of the tools shows that the edges of handaxe 17 actually converge more rapidly towards the point when compared to number 11.

The final class is the ovates, which are made up of handaxes 1, 2, 4, 5, 7, 8, 10, 12, 13, 14, 15, 18, 20, 21, 22, and 25. Of these, number 7 has been misclassified, as this tool is quite clearly of pointed form (see Figure 5.6). It also stands apart from the rest of the ovates in the scatter diagram. The reason for this is likely to be the fact that this handaxe has a low value for its relative location of maximum width. This has been caused by the shape of the cortical butt present on this tool. The tightest cluster of handaxes within this zone includes numbers 1, 2, 5, 12, 15, 20, 21 and 22. This is justified, as all of these tools are roughly similar in shape, the majority being ovate or cordiform in shape. The remaining handaxes lie around this cluster, with several situated just below Zone III.

The results of Bordes' typological method were also compared to the results of the visual analysis described above and the known identities of the tools creators. As can be seen in Figure 5.9, the visual analysis of the tools compares relatively well to the results of the Bordesian method, with only Groups 5 and 6 showing less definition and being more spread out through the four zones. Figure 5.10, however, clearly shows that the typological divisions suggested by the Bordesian method do not reflect the knappers who produced the tools, nor does there appear to be any correlation between tool shape and the individual. Only Knapper 5's tools, which include handaxes 9, 17 and 19, cluster together in Zone III. The ovate handaxes produced by Knapper 1 also cluster relatively closely together. However, the tools of two of the knappers do not cluster closely at all. Finally, the majority of the tools classed as ovates cluster tightly, making it impossible to use the results of this typological method to separate the tools based on their creator.

Roe's Typology

Roe's methodology is similar to that of Bordes, although a few specific measurements differ. In addition to Bordes' measurements, Roe requires measurements of the width one fifth of the total length from the tip and butt of the tool (Figure 5.11). Using these measurements the tools can be plotted onto a tripartite diagram by calculating the breadth:length ratio and the relative pointedness of the implements:

- The breadth:length ratio (i.e. elongation) is calculated by dividing the maximum width of the tool (B) by its maximum length (L). This provides a scale that indicates how narrow or broad the tool is (Roe 1981: 157).

- The relative pointedness of the tool is shown using the ratio of the width at the tip of the tool (B_1) versus the width at the butt (B_2).

Once calculated, the values are plotted in a series of three scatter diagrams that make up the tripartite diagram (Figure 5.12). Handaxes are attributed to one of the three plots based on their outline shape (Roe 1964, 1968; 1981: 156-7), which is expressed by the location of the maximum width of the tool relative to the total length (butt length/length or L1/L). Roe calculated this using a similar method to Bordes' relative location of maximum width. However, the ratio is inverted to give scores between 0, meaning the maximum width location is along the butt of the handaxes, and 1, where the tip would be the widest point.

Roe assigned handaxes to an outline shape class based on the values of this calculation, with those tools showing values below 0.350 assigned to pointed classes (the right hand plot), those with values between 0.350 and 0.550 assigned to ovate classes (the middle plot), while the remaining tools are assigned as cleavers (the left hand plot). This division is somewhat arbitrary. The results of the typological assessment of the replica assemblage according to Roe's methodology are given in Table 5.3.

The tripartite diagram for the replica assemblage is given in Figure 5.13. The tools are divided into points and ovates. None of the tools studied were classified as cleavers using Roe's typology. Handaxe numbers 3, 6, 9, 11, 16, 17, 19, 23, 24, and 26 were all classified as pointed forms. Handaxes 23 and 16 cluster closely together, which appears appropriate due to their similarity in shape. Both also display chamfered butts, though this is not accounted for in the measurements taken. It is also interesting to note that these tools do not cluster closely together in when Bordes' typology is applied, although they are so similar in shape. Handaxe 19 also clusters close to these two tools, and if its butt was rounded would appear closely related in shape. However, although it shows similarities in edge and tip shape, this tool is situated in the upper right quadrant of the scatter diagram. Handaxes 9 and 24 also fall into this region. While the tripartite diagram would suggest that number 9 has a more rounded tip, it clearly displays a definite convergence to a pointed tip. Handaxe 24 is also suggested to be a rounder and fatter tool by the diagram, but in reality is of cordate shape when visually analysed.

Handaxes 6 and 26 do not cluster as closely as expected, which may be due to the fact that number 26 is missing a part of the butt on one side due to a flake removal. Handaxe number 3 also appears in this lower left quadrant and all three of these tools exhibit a similar triangular outline. Finally, handaxes 11 and 17 are found in the upper left quadrant. Both are similar in terms of relative 'narrowness'. However, handaxe 17 is classed as having a rounded tip, whereas in reality it displays a more pointed tip. The cause of this is suggested to be the fact that the tool converges rapidly near the tip, while the edges are equivalent to that of a pointed handaxe. Handaxe 11, on the other hand, displays an arguably more pointed tip that number 17.

The remaining handaxes (1, 2, 4, 5, 7, 8, 10, 12, 13, 14, 15, 18, 20, 21, 22, and 25) were classified as ovate forms. None of these handaxes were plotted in the lower two quadrants of the ovate scatter diagram, which encompasses the more pointed forms. Of these tools, only handaxes 14 and 22 cluster very closely and both are rather crude. However, these do not compare very well in terms of their overall shape, with handaxe 22 displaying a much more pointed tip in comparison to the rounded shape of number 14. Handaxes 2, 5 and 21 all cluster closely with numbers 14 and 22. In terms of overall shape they are all very similar. However, numbers 2, 5 and 21 are narrower in profile.

Handaxes 2, 12, 15, 18 and 20 are all well represented by the shape diagram, with the overall shape of each matching what Roe's suggests in his published 'key'. Handaxes 4 and 10 are situated relatively close together, although it was expected that these would show a greater relationship. However, their separation can be justified due to number 4 being narrower and more elongated. In terms of tip shape, though, they are very similar. Finally, handaxe 7 is found to the far left of the ovate shape diagram, although this tool is recognised as a pointed form. It appears that this is again due to the fact that the location of the maximum width is more central for this handaxe. The unusual shape of its butt has also affected the measure of relative pointedness, which has resulted in its misclassification. This serves to highlight issues in misclassification of tools due to variation in outline shape that affects the measurements taken, in turn affecting the results of this metrical analysis.

In the same manner as for Bordes' typology, the results were compared to the visual analysis and the known identities of the knappers involved in the assemblage's production. As shown in Figure 5.14, the results of Roe's typology match relatively well to the visual analysis, though there is some cross over between the point and ovate shape diagrams in the case of Groups 1, 5 and 6. However, crossover within Group 6 is a result of handaxe 7 being misclassified and, therefore, can be ignored to some extent. Figure 5.15, on the other hand, shows that when the knappers of the tools are mapped onto the results it is apparent that there is little separation of the tools based on their creators. There is also a distinct difference between the results from Roe and Bordes' typologies. The main, and perhaps most interesting, of these differences is that the products of Knapper 1 and 5 no longer cluster tightly with their counterparts, showing a much higher degree of separation. Again, due to the high degree of overlap between tools produced by the different knappers, Roe's typological method is unsuitable for analysing the individual behind the production of the these tools.

Wymer's Typology

The final typological assessment of the replica assemblage was conducted using Wymer's (1968, 1985) more qualitative method. This system aims to group handaxes in terms of their outline, tip and butt shape. Wymer identified ten different categories of Lower Palaeolithic handaxe, many of which would grade into one another producing a variety of sub-categories. These ten categories can be summarised as follows (after White & Plunkett 2004: 168):

- D – Crude, stone struck handaxes.
- E – Small (less than 10cm) and irregular forms.
- F – Pointed forms.
- G – Sub-cordate forms.
- H – Cleavers.
- J – Cordate forms.
- K – Classic ovate forms.
- L – Choppers.
- M – Ficrons.
- N – Flat butted cordate forms, similar to the bout-coupé handaxes seen in the Mousterian.

As a result, a graphical key for the typology was produced to aid in making determinations of artefacts based on their overall shape (see Figure 5.16). The artefact classes can be further refined to indicate the type of butt, tip and edge present on the tools (see Table 5.4). While these refinements were recorded for all twenty-six handaxes present in the replica assemblage, the review of Wymer's typology presented below focuses primarily on the differentiation of the tools into the classes and sub-classes given in Figure 5.16. The results of this typological analysis will now be discussed.

Category E (Small and Irregular)

Only number 22 fits into this class (see Figure 5.17), due to its crude nature and size of 8.65cm. Its crude nature may be a result of poor raw material quality.

Category F (Pointed)

Five handaxes (3, 6, 7, 11, and 26) are considered to be purely pointed types (Figure 5.18). Of these, handaxes 3 and 7 display rounded tips and natural, untrimmed butts. Handaxe 6 also has a rounded tip, while its butt is flat. Finally, numbers 11 and 26 both have trimmed butts, though handaxe 26 still retains some cortex. The tip shape of these two handaxes contrasts though, with 26 displaying a rounded tip, while 11 has a basil point. However, the tip shape for number 11 may have been caused by an excessive removal in the later stages of manufacture or re-sharpening and, thus, may not have been intentional.

Category G (Sub-Cordate)

Two handaxes, 9 and 14, are classed as type G (Figure 5.19). Both have distinctive wide and thick butts. However, handaxe 9 appears to be worked to a much higher degree and displays an acutely pointed tip. Handaxe 14, on the other hand, has a much more rounded tip, similar to ovate tools.

Category J (Cordate)

There are four tools that are classed as cordates. These include handaxes 1, 5, 13 and 24 (Figure 5.20). All of these tools show a straight edge in profile. Handaxe number 5 also shows evidence of a tranchet removal across the tip.

Category K (Ovate)

Six of the handaxes can be classified as type K. These are number 2, 8, 10, 12, 15, 18, 20 and 21 (Figure 5.21). All these tools display a straight edge in profile, with no tranchet removals evident. In must be noted that handaxe 10 may be classed as a type L segmental chopping tool, though the extent of working around the tip and butt of this tool suggests otherwise.

Sub-category FG (Pointed Sub-Cordate)

Handaxes 16, 17, 19 and 23 are classified as pointed sub-cordate forms (Figure 5.22). Numbers 17 and 19 are very similar in shape, although 17 displays an *ogee* tip, while 19's is more rounded. Handaxe 16 and 23 display similarly shaped butts with chamfered corners. These may have been intentionally created, though it is more likely that their occurrence is a result of raw material factors. That they were left in this manner may indicate a level of aesthetics applied to the finished products.

Sub-category GK (Ovate Sub-Cordate)

Only handaxe 4 has been placed in this sub-category, due to its elongated ovate shape (Figure 5.23). The thickness of this tool supports this attribution.

Sub-category JK (Ovate Cordate)

Only handaxe 25 fits within this category (Figure 5.24). This tool is suggested to correspond well to this type, due to the fact that is displays a twisted profile.

When the results of this typological analysis are compared to the known identities of the knappers it is clear that Wymer's methodology is also unable to establish links between the tools based on their creators (see Table 5.5). None of the categories was able to group the tools of a particular knapper correctly, although the sub-category GK contains only the product of Knapper 3. However, this knapper produced one single tool, whereas knappers producing multiple tools have their products spread amongst the different categories.

It is worth noting, however, that the products of single individuals dominate some of the categories. For example, category K consists of eight handaxes, five of which were produced by Knapper 1. Also, Knapper 2 produced two of the four handaxes that make up category F. This may suggest that the knappers involved in the production of the replica assemblage have a predilection for a specific shape or style of handaxe and this is reflected in the typological assessment of the tools.

When compared to the results of both Roe and Bordes' typologies one can see a degree of correlation (see Table 5.5). However, there is some disparity between them. The main example of this is shown by handaxe 7, which both Roe and Bordes' methods class as an ovate form, while the visual analysis provided by Wymer's typology clearly describes it as pointed. In addition, Wymer's method describes handaxe 24 as cordate, which agrees with the Bordesian analysis, but differs from Roe's, which classes this tool as a pointed form. Despite these slight differences, all three typological methodologies produce relatively similar results, though each differs in the overall number of types produced.

Summary

The three different typological methods discussed above have all shown an ability to divide the tools from the replica assemblage into a series of types with a relative degree of accuracy. However, those that rely upon measurements alone displayed errors, especially in describing handaxe 7. Although this is a single case, it demonstrates that a reliance on measurements is sometimes not satisfactory and that such methodologies must also be supported by visual analysis in order to detect such anomalies.

Finally, none of the typological methods was able to accurately group the tools in a manner that was representative of the knappers involved in their production. This demonstrates quite clearly than knapping idiosyncrasies go beyond simple differences in shape. However, to be fair to the original workers, it is important to note that identifying individuals was never the aim of their methods, which were geared towards identifying higher levels associations. It is, therefore, my aim to try and move beyond this and aim to analyse the tools at a deeper level. However, it is interesting to note than the knappers involved in the replica assemblage appear to have a preference for specific shapes. For example, Knapper 1 produces more classically ovate handaxes, while Knapper 2 is seen to create more pointed forms. Knapper 5's tools also appear to grade between cordate and sub-cordate in their shape. As mentioned in the discussion of the visual analysis, however, this theory may be the result of a sampling bias. Therefore, a larger and more rigorous experimental analysis is required prior to acceptance of this hypothesis.

A MORPHOMETRIC ASSESSMENT

As mentioned in the introduction to this chapter, there are numerous other methods of analysing the morphology of stone tools. One of these methods is morphometric analysis. Therefore, a morphometric study of the replica assemblage was conducted, which focused on two main factors through which individuals may be expressed; outline morphology and edge morphology. The results of each of these analyses were also compared to those from the typological methodologies discussed above, as well as the known identities of the knappers who produced this assemblage.

Analysis of outline morphology

The morphometric analysis of the overall shape of the handaxes was conducted in a similar manner to that carried out by Wynn and Tierson (1990). However, a total of twenty-four measurements were taken for each tool. These measurements were taken along rays extending from the midpoint of the long axis of each handaxe, with each ray spaced 15° apart (see Figure 5.25). The equal spacing of these rays was chosen to provide as accurate a representation of the overall shape of the tool as possible, as opposed to Wynn and Tierson's method, which focuses primarily on the tip and butt shape (1990: 74).

During the production of the measurements, each handaxe was placed on a sheet of paper with lines radiating outwards at 15° intervals from a central point. The handaxes were positioned so that its midpoint was centred over this central point (see Figure 5.26). A 50mm scale bar was also included. Each tool was then photographed using a Fujifilm 8 Megapixel digital camera mounted on a tripod. Once photographed, the images were imported into ImageJ (version 1.41o), in order to produce a series of Cartesian coordinate landmark measurements at the point where the radiating lines intersected with the outline of each handaxe. In order to produce measurements in millimetres, as opposed to pixels, the scale was set for each image using the scale bar. The measurements for each of the tools were then compiled into a single dataset.

A Generalised Procrustes analysis was then applied to the data using the program tpsRelw (Windows, version 1.49). This rescaled the data to remove the size variation, while also minimising differences in position by rotating and translating the recorded coordinated. Finally, the rescaled data was then subjected to a principal component analysis to explore the variation in shape within the sample.

Results

The results of the principal component analysis are displayed in Table 5.7. The presence of zero sum eigenvalues within the results is suggested to be the result of a low number of cases (n=26) in comparison to the overall number of variable present from the landmarks recorded (n=48). Though the results of this analysis can only be tentative, the fact that the resultant scatter diagrams compare well with the typological analyses, as discussed below, indicates the results of the principal component analysis provide some correlation in terms of the overall variability in outline shape.

A total of six components with eigenvalues greater than 1.0 were extracted from the principal component analysis, as seen in Table 5.7:

- The first three components appear to be responsible for the majority of the variance within the sample, accounting for 85.35% of the variation.
- The remaining components account for a much smaller amount of variation.

Therefore, the first three components were used in the exploration of shape variability within the sample and were plotted as scatter diagrams (Figure 5.27).

Both the first and second components appear to account for variation along the top left and bottom right edges of the handaxe, describing variation in the placement of these landmark measurements. Component one specifically appears to represent differences in the elongation of the tools and width of the tip and butt, with the variance centred along the left edge of the tip and right edge of the butt (see Figure 5.28a). Component two, on the other hand, appears to display variation in the length of the tip and, to a lesser extent, the length of the butt area, as well as elongation around the middle of the tools (see Figure 5.28b). Component three corresponds to variation in the tip and the left edge of the tools near the butt, which appears to represent the variation in the width of these areas (Figure 5.28c).

There is a noticeable separation between pointed and ovate forms within the graphs that include component one, with points lying to the right of the scatter diagram and ovates to the left. This is much less apparent in the scatter diagram of component two versus component three. This suggests that it is component one that mainly reflects the overall morphology of the handaxes examined. Therefore, the results were interpreted using only those diagrams that include component one.

Ovate forms within the assemblage tend to show much lower variation in their overall shape and cluster much closer together when compared with the pointed forms. Interestingly, handaxes 17 and 19, which were considered to be very similar in the visual analysis, do not cluster together in the comparison of components one and two. This is potentially a result of the method of analysis, especially considering that these two tools do not display symmetry along their long axis. This may also explain why handaxe 17 does not cluster with the other tools present. However, these two tools are situated close together when component one and three are compared. In addition, handaxes 4 and 7 do not appear to cluster with the rest of the assemblage when component one and two are compared. This may be explained by the fact that both handaxes 4 and 7 present variations in shape that have no parallels amongst the other tools. As discussed in the typological analyses above, handaxe 7 was misclassified as an ovate due to the measurements used. Therefore, it is possible that its shape may have resulted in its separation from the rest of the tools in the principal component analysis, based on the landmark measurements taken. Handaxe 4 also displays a different shape, being much more elongated in comparison to the other tools.

When compared to the results of the Bordes' and Roe's typologies, there is a clearly a great deal of similarity, especially where component one is concerned (see Figures 5.29 and 5.30). The morphometric analysis reflects the division between pointed and ovate forms that Roe's typology suggests, with little cross over between these classes. In terms of Bordes' typology, there is a little more cross over between his four types, though the triangular handaxe 6 lies at one end of the diagram, while the ovate forms are found at the other. However, the sub-triangular and cordate classes show a much greater degree of variability and overlap. Wymer's typology also compares well with the morphometric analysis (see Figure 5.31), despite the fact that it is based on a visual assessment of the tools. Overlap is most prominent in the ovate forms, while the division between the more pointed forms governed by categories F and FG is much clearer. This may be due to the fact that pointed forms appear to be much more variable and, thus, are easier to differentiate between. On the other hand, the limited amount of variation within the ovate forms suggests that it is more difficult to pigeonhole these tools into types in a satisfactory manner.

Finally, the results of the morphometric analysis were also compared to the known identities of the knappers (Figure 5.32). In a similar manner to the typological methods, the morphometric analysis is unable to group the tools according to the knappers who produced them. However, it does appear to show that the ovate tools produced by a particular knapper tend to be similar in morphology to one another. For example, both Knapper 1 and Knapper 4's ovate tools tend to cluster with each other. Similarly, the pointed forms also show some degree of similarity, though any clusters are spread further. Knapper 1's handaxes (numbers 23 and 26) are most closely associated, though Knapper 2's pointed forms are also grouped together. However, this is not true of all the knappers. The most obvious example is Knapper 5, whose tools do not cluster in any meaningful way that can be related to their creator. It is apparent that, while the overall morphology of the tool is linked to the knappers' goals and idiosyncratic knapping strategies, we must strive to go beyond this when trying to identify individuals in stone tool assemblages.

Analysis of edge morphology

Edge morphology was analysed using a similar methodology to the analysis of the overall morphology. Ten landmark measurements were recorded along both edges of each tool as shown in Figure 5.33. In order for the edges to be compared against one another, the images were flipped vertically, so that the recordings of each edge produced similar outline shapes. Once recorded, a Generalised Procrustes analysis was applied, prior to using principal component analysis to explore the data further.

Results

The results of the principal component analysis are shown in Table 5.8 and are plotted as scatter diagrams in Figure 5.34. Three components with eigenvalues greater than 1.0 were extracted from the principal component analysis. These account for 88.69% of the total variation within the sample:

- Component one displays variation along the majority of the edge. This mainly corresponds to variation along the y-axis along the middle of the edge, which correlates to differences in the width of the tools (Figure 5.35a).
- Component two appears to represent variation in the x-axis within the landmark measurements taken closer to the butt of the tools (Figure 5.35b). This suggests that this component is likely to correlate to differences in the distance from the butt to the point of maximum width, leading to elongation or shortening of this area.
- The final component represents a much smaller amount of variation, which appears to be governed by differences in the breadth of the tip and elongation of the butt of the tools (Figure 5.35c).

The scatter diagrams show a division between ovates and points in a similar manner to that seen in the overall morphological analysis, especially where component one is included. When components two and three are compared, this division is lost. For this reason, component one is considered to be highly representative of the overall variation in edge morphology and only those diagrams that include this component were used for the interpretation that follows.

The comparison of the left and right edges appears to show that ovate forms have the highest degrees of correlation, with handaxes 4 and 20 show the greatest amount of clustering. It is also interesting that the edges of three handaxes appear to straddle the y-axis of the scatter diagram. Handaxes 9 and 25 appear to be represented equally on either side. However, handaxe 24 displays one edge that sits towards the more pointed tools, while the other is clearly associated with ovate the forms. This is considered strange, given that this tool appears very symmetrical from a visual assessment. A comparison with the results of the typological analyses shows that handaxe 24 is classified as a pointed or cordate form. It may be that the difference between the morphology of the two edges has had some effect on these metrical analyses, while a visual assessment of the tool suggests that this is a definite cordate shape, as suggested by Wymer's typology.

When compared to the results of Roe's typology, there is a division between pointed and ovate forms (see Figure 5.36). It also shows how the left edge of handaxe 24 sits amongst the ovate group, though it has been classified as a point. This is also evident in a comparison with the results of Bordes' typology (see Figure 5.37), where handaxe 24 is classified as cordiform. Handaxe 7, which clusters with the pointed forms stands out in these comparisons as well. However, this result can be ignored, as handaxe 7 is considered to be a pointed form, rather than ovate as suggested by the typological methods. Wymer's typology also displays a reasonable correlation with the results of the principal component analysis (see Figure 5.38), although there is a degree of crossover between the different categories. This emphasises the difficulty of accurately dividing the tools according to a visually based assessment of tool morphology. However, it is noted that handaxe 24, despite the differences in the morphology of its edges, clusters with the other cordate handaxes.

When the known identities of the knappers are compared with the results from the analysis of edge morphology, it is again clear that there is no correlation between knappers and edge shape (see Figure 5.39). There is a much higher degree of spread compared to the results of the overall shape morphology and the products of each knapper do not cluster together. Both Knapper 1 and Knapper 2, whose tools clustered together to a reasonable extent in the analysis of overall morphology, display much less cohesive groups. Only Knapper 3's handaxe displays a clear relationship in its edge morphology and stands apart from the rest of the tools in the assemblage. However, due to the fact that this knapper only contributed a single tool, it is impossible to conclude that all of their handaxes would act in a similar manner. Therefore, it would be necessary to analyse a larger dataset in which each knapper contributed a larger number of tools before any firm inferences can be made.

DISCUSSION AND SUMMARY

This chapter has explored the handaxes from the replica assemblage using both visual study and traditional typological techniques, as well as a landmark based morphometric analysis. These different methodologies have been able to differentiate tools into types based on both visual and metrical evaluation of the artefacts. However, none of the techniques used were able to provide an accurate division of the assemblage based on the knappers who had created it. While this is true, the various analyses have revealed some interesting points.

The first of these is that a simple visual analysis of the assemblage, base solely upon the examination of similar 'eye-balled' traits, is able to group the products of the same knapper together to some extent. Of the six groups suggested, the majority are dominated by the products of a single knapper. Despite a large margin for error, it appears that such a visual analysis is able to detect, in part, idiosyncrasies that relate tools to their creators. Again, this is important, given that the visual ability to identify people through their products would have been a major factor in the lives of hominins, otherwise imposing oneself on material culture would have been a pointless endeavour. If we deny this then we must accept that an object has resonance only when it is in the hand – once it is discarded it is no more than a pebble on the beach. However, a visual study is not nearly reliable enough to perform a rigorous analysis of an archaeological assemblage, especially when the results cannot be checked to determine their accuracy. Even so, this revelation may add weight to the suggestion that the same knapper created certain tools in the archaeological record, such as handaxes #42 and #48 from Foxhall Road (White & Plunkett 2004).

The typological methods discussed are able to classify tools based on visual and metrical analysis and are generally in agreement with each other. However, it has been shown that those methodologies that rely upon measurements exclusively can result in the misclassification of artefacts that present unusual or non-traditional shapes. The main example from the replica assemblage is handaxe 7, which was wrongly attributed to the ovate group by both Bordes' and Roe's methods. None of the typologies was able to accurately group the tools according to their knappers. However, it was interesting to note that knappers appear to show a preference for specific shapes of tools, though this needs to be confirmed through the analysis of a larger dataset.

Finally, the morphometric analysis correlates well with the results from the typological studies conducted, though it clearly reveals errors in them. It shows the accuracy of Bordes' and Roe's typologies and agrees with Wymer's, though it demonstrates that there is a large degree of overlap in the latter's classifications. It also demonstrates that there is a much greater degree of variation in pointed tools when compared to ovates. This is true for both the analysis of outline morphology, as well as edge shape. It would appear to confirm the suggestion that the knappers involved in the production of the replica assemblage favour certain morphologies. The main examples of this are Knapper 1's preference for ovate forms and Knapper 2's production of similar pointed tools. Despite this, the morphometric analysis is also unable to attribute the tools to their knappers and, as with all the other methods, cannot link ovate and pointed tools together based on their creators.

Overall, the outcome of these studies serves to demonstrate that, despite there being evidence for shape preference amongst the knappers, analyses that seek to study the individuals behind an assemblages production must be able to go beyond the examination of overall morphology. Instead, they must strive towards a deeper and more meaningful analysis of idiosyncrasies that can be linked to the knappers involved in an assemblage's production. Only then can they truly answer questions at the level of the individual.

CHAPTER SIX

REFITTING THE INDIVIDUAL

INTRODUCTION

As has already been discussed, most previous studies of Palaeolithic material culture have focused on refitting assemblages in order to answer questions about both behaviour and agency (Pigeot 1990; Pope 2004; Pope & Roberts 2005; Schlanger 1996). This seems appropriate given that these represent the fossilised acts and goals of the hominins who created these knapping sequences. However, while these studies have established that such sequences are the acts of individuals, there has so far been no attempt to examine whether the imprint of an individual's knapping technique can be traced across multiple refitting groups. If Gunn (1975) is correct and knappers do leave an individual mark in knapping technique and tool form, then tracing individuals through these sequences is, theoretically, an achievable goal.

This chapter will present the results from the analysis of refitting groups from both the replica and archaeological assemblages and aims to show whether the actions of individual knappers can be isolated and traced within those groups. In each case, the methodology outlined in Chapter Three was applied. Each sequence of flakes was refitted as completely as possible and then deconstructed (where able) noting qualitative differences in reduction techniques, as well as recording qualitative data across eight variables suggested to be linked to knapping idiosyncrasies (see Chapter 3, 47). The resultant data was then analysed using both principal component and cluster analysis in order to explore the results further. A brief description of each refitting group has been provided, which details the interpretation of the knapper's progression seen in each of the knapping events studied. This was used in conjunction with the qualitative assessment of the sequences studied in order to draw forth conclusions regarding the methodologies ability to detect instances of knapping idiosyncrasies and whether these could be linked to individual knappers. The initial replica sample has already been published (see Foulds 2010), but is presented here in further detail.

THE REPLICA ASSEMBLAGE

A total of eight handaxes were selected as a cross section of the replica assemblage and re-associated with their débitage. The tools selected showed a variety of different shapes and sizes (see Figure 6.1). In addition to these, a knapping sequence comprising débitage with no associated handaxe was supplied. As stated in Chapter Two, this additional sample provided a control to show whether the absence of the tool affected the interpretation of the refitting sequence through an a priori, if tacit, assumption that the handaxe was the product of a specific individual. Each sample of débitage was refitted using Blu-tack as opposed to a traditional adhesive, with the associated handaxe at the core where appropriate. Blu-tack was used so that the knapping sequence could be deconstructed once fully refitted and, thus, analysed flake by flake. As each flake was removed the sequence was photographed and a description of the knappers actions was recorded, in addition to the variables required for the analysis. A brief description of each of the sequences is presented below[3].

Refitting sequence A

Refitting sequence A consisted of a total of 47 flakes and the associated handaxe (#9). During the refitting process, an issue with the use of Blu-tack as an adhesive was encountered. The flint used was black to grey in colour with some patination and grey quartzite running throughout. The cortex is grey to white with a lot of sand. It was found that the particular flint used in the production of this sequence did not enable a lasting bond to be made. Therefore, the analysis could not be performed on a fully refitted block. Additionally, a complete photo record of this sequence could not be produced. However, through the use of the associated handaxe, the sequence could be adequately followed. Still, it is important to note that this may present an issue in the interpretation of the sequence.

[3] All descriptions of the refitting are in the first person, so that the sequence is described as if each flake was being removed. This is to illustrate how the process of reduction advanced from the knapper's point of view. In addition, all descriptions of rotation are described as if the knapper were turning the nodule in hand.

The knapper begins by removing several flakes [1-6] in an apparently random pattern, moving from one area to another with no way to accurately document the progression of the sequence. These flakes are removed using a hard hammer technique on unprepared cortical platforms. It appears from this approach that the knapper is preparing the nodule, as subsequent removals follow a more strategic approach. The knapper then begins to work clockwise around the edge of the nodule to prepare the blank [7-10]. Again, no platform preparation is seen, though there is evidence of skill in the correction of a hinge fracture.

The blank is then flipped and a large flake is removed to create a platform. Turning the blank over through roughly ninety degrees, the knapper works anticlockwise along this platform [12-15], before rotating the blank back to the beginning of this sequence of removals and removing a further three flakes. All of these removals continue to show no evidence of platform preparation and all display feather terminations.

The blank is then rotated through 180 degrees and a series of flakes are removed, rotating anticlockwise, to set up a platform [19-22], followed by flipping the blank and removing a thin flake across the end. Again, there is no evidence for platform preparation, but the small nature of the platforms suggests a possible switch between hard and soft hammer technique. The blank is then flipped through 90 degrees and, rotating anticlockwise, a further series of flakes is removed [24-26] before removing the final large flake from the sequence. The knapper then proceeds to rotate anticlockwise, removing nine further flakes [28-36]. Of these, none display platform preparation, and two [34 & 36] show hinge/step fractures, though these are likely due to the quality of the raw material.

Final thinning of the handaxe then proceeds from roughly opposite the location of the last removal. The knapper rotates clockwise, removing three flakes [37-39], before flipping the blank and rotating anticlockwise around the edge of the tool [40-45]. These flakes are often fragmentary and also, in some cases, display evidence of platform preparation [41-42]. The knapper then flips the blank, removing four more flakes, before turning it over on final time and removing the last three refits. The direction of rotation cannot be determined for these final flakes, as the absence of other refits does not allow an accurate prediction of the sequences trajectory to be formed. All of these final removals show evidence of platform preparation.

Refitting sequence B

Sequence B consisted of 32 refitting flakes and their associated handaxe (#23). A grey patinated flint was used in the production of this pointed tool. The initial removal is missing from the sequence, but the resultant scar suggests a hard hammer flake designed to remove a large amount of the outer cortex (Figure 6.2). The knapper then flips the nodule and removes another large flake, before returning to the previous face and using the platform created by this removal to strike off another large flake, which subsequently shattered, resulting in a step fracture [2-3] (Figures 6.3 and 6.4). They then rotate anticlockwise and remove a further flake, which terminates early in a hinge fracture [4] (Figure 6.5).

The sequence then moves around to opposite these removals and three flakes are produced [5-7] from roughly the same location (Figure 6.6), the last of these being a large hard hammer flake that has split in two across the midpoint of the horizontal axis and terminates with a lip. The knapper then rotates through 180 degrees and removes a further flake, successfully removing the ridge in the raw material and the scar left by the previous removal [8]. Rotating anticlockwise from this, the knapper then removes a further flake, which also appears to have shattered with a hinge fracture termination [9] (Figure 6.7).

The knapper now turns the developing blank over and starts to reduce the opposite side, working by rotating anticlockwise [10-11] (Figure 6.8). Platform preparation is seen on these flakes, but terminations tend to be hinge fractures. They then redirect their attention to the other edge of the blank, removing four flakes while again rotating anticlockwise [12-16] (Figures 6.9 and 6.10). Little evidence of platform preparation is seen amongst these flakes. The initial flake in this small sequence forms a very large step fracture, and it appears that the majority of the subsequent flakes are designed to fix this issue.

Moving to the other edge, the knapper removed a large flake that extends over the centre of the blank [17], followed by several smaller removals that are accessed through rotating the blank anticlockwise [18-23] (Figure 6.10 to 6.12). The later flakes from this group appear to be attempts to thin a ridge in the raw material near the butt of the axe. They show some preparation, but mostly result in hinge terminations [19-21 & 23]. Unable to remove this ridge from this angle, the knapper returns to the tip of the axe and removes a long flake [24] in an attempt to correct previous mistakes (Figure 6.13), followed by two more flakes [25-26] (Figure 6.14), having rotated the blank clockwise. Neither of these manages to remove the protrusion.

The knapper then focuses on reducing the tip of the axe, removing three flakes [27-29] (Figure 6.14), some of which show evidence of being prepared. They then flip the blank and remove the final three refitting flakes [30-32] (Figure 6.15). Finishing of the axe consisted of chipping around the edges. However, these flakes could not be refitted accurately. Scar patterns indicate that these removals resulted in a lot of small hinge and step fracturing where flakes were unable to fully form before detaching.

Refitting sequence C

This refitting sequence was the largest of those studied, with a total of 64 refitted flakes. The handaxe associated to this sequence was #21. The raw material used was a grey flint with lighter grey patination and a chalk cortex. The knapper begins by removing a large protrusion and large volumes of the cortex from one side of the nodule [1-3] (Figure 6.16). They then flip the nodule over and remove further cortical flakes, rotating clockwise as they do so [4-7] (Figure 6.17). The knapper flips the blank through 90 degrees to removal another small cortical removal [8], before removing a large hard hammer flake from across the surface of the nodule [9]. There is no platform preparation on these flakes. Instead the knapper uses natural platforms exposed throughout the knapping sequence.

The knapper then flips the blank, removing a flake from the same location as prior removals [10] (Figure 6.18), before returning to the previous face and removing a flake from the side of the nodule [11]. This sets up a platform for the removal of another large hard hammer flake struck across the nodule [12] (Figure 6.19). The knapper flips the blank over once more to remove two flakes, rotating anticlockwise [13-14] (Figure 6.20), before turning back to the previous face and removing two flakes that set up platforms for future removals [15-16] (Figure 6.21). They continue flaking around the blank, alternating between the two faces and removing a further three flakes [17-19] (Figure 6.22 and 6.23).

The knapper then concentrates on a protrusion near the bottom of the nodule, working anticlockwise around it [20-27] (Figures 6.24 to 6.27). Once removed, the knapper begins to thin the blank, alternating between clockwise and anticlockwise rotations and turning the blank after every three to four removals [28-39] (Figures 6.28 to 6.33). These flakes also begin to show evidence of platform preparation. They then proceed to final thinning of the handaxe, again, alternating between clockwise and anticlockwise rotations [40-64] (Figure 6.33 to 6.39). These flakes show further platform preparation, and occasional fracture. The majority of display feather terminations, though some end in hinge fractures [e.g. 53].

Refitting sequence D

Sequence D consisted of the additional sample of débitage that lacked an associated handaxe. Due to the lack of a tool around which to reconstruct the nodule used, the smaller and more fragmentary flakes were almost impossible to refit. In addition, the refitting had to be done in several separate sections, rather than once continuous sequence. The raw material used was a grey flint, with some iron staining and quartz flaws throughout.

Section One

This section is the largest, consisting of 21 flakes. The initial removal is missing, though it is possible to tell that this was a hard hammer cortical flake. After rotating clockwise, a second large flake is removed. The knapper then moves to the other side of the nodule, removing a series of flakes [3-6] and, for the most part, rotating the nodule anticlockwise (Figure 6.40). They then rotate clockwise, removing two flakes that both split during knapping [7-8], before returning to where the initial removals were taken. Continuing to rotate clockwise, the knapper removes two long flakes [9-10] (Figure 6.41 and 6.42), correcting a hinge fracture introduced earlier [6]. A further long flake is removed [11], before turning the blank through 180 degrees.

From this point, the knapper removes an elongated flake that terminates with a slight hinge [12] (Figure 6.42). The next flake may be to correct this, but results in a further large hinge fracture [13]. The knapper then rotates anticlockwise and removes a flake to correct this, which subsequently fractures on impact [14] (Figure 6.43). The remaining flakes amount to thinning of this surface [15-21] (Figure 6.44), displaying some platform preparation. Establishing the order and rotation of removals was difficult with the absence of the associated tool.

Section Two

Section two consists of just five flakes. The first displays a prepared platform, and is followed by a further four removals, alternating between opposite sides of the blank. Some flakes indicate the presence of hinge fractures [2-5] (Figure 6.45 and 6.46). The presence of flake scars on the dorsal surface of these flakes shows that there are prior removals that are missing from this sequence.

Section Three

This section was made up of 9 flakes (Figure 6.47 and 6.48). The majority of the flakes are removed as the knapper rotates the blank anticlockwise, though some clockwise rotation is seen. The butts of most of the flakes are crushed or shattered, making platform preparation difficult to see. Again, there is evidence that several flakes are missing from the sequence.

Section Four

Section four consists of just three flakes (Figure 6.49 and 6.50). It displays consistent anticlockwise rotation to remove these flakes. Platforms are crushed or missing, though termination is feather, except for the initial removal, which displays a hinge termination.

Though difficult to interpret, the quality of the raw material and level of hinge fractures seen throughout the sequence suggests that the former may have directly influenced the occurrence of these mistakes. Platform preparation and the ability to correct mistakes suggest that the knapper may have had some skill at obtaining the results they desired.

Refitting sequence E

Sequence E consists of the cordate handaxe #14 and 47 refitting flakes. The raw material used was a grey flint with a chalk cortex. The initial removal is along the side of the nodule, where the butt of the handaxe develops, and shows a step fracture termination. The knapper then removes the entirety of this area (Figure 6.51). The ventral surface of the second flake shows multiple ripple marks travelling in opposing directions, which may indicate several attempts at removal from different platforms. There are also three other flakes [3-5] that, while connected to the sequence, do not factor into the reduction of the axe studied here. This may indicate another part of the nodule was used in the production of another tool.

Reduction of the nodule begins properly with the removal of a large flake from the 'bottom' [6], followed by a smaller flake, which is probably in error, and a much larger cortical flake [7-8] (Figure 6.52). Another flake is then removed from the bottom of the nodule, before knapping from the opposite edge [9-10] (Figure 6.53). The blank is then turned over and a flake is produced using the scar from the previous removal as a platform [11] (Figure 6.54). The knapper then returns to the previous face and removes a second flake similar to #10, again using the scar from the previous removal as a platform.

Returning to the bottom of the blank, the knapper removes three flakes, rotating the blank clockwise [13-16] (Figure 6.55). They then turn to the other face of the blank, remove a single face and turn back (Figure 6.56). A series of flakes is removed from this platform while continuing to rotate the blank clockwise, occasionally returning to remove obstructions [18-38] (Figures 6.57-6.60). Here, the knapper is thinning this face of the axe, and platform preparation become more common with the later removals.

Turning the blank over once more, the knapper finishes thinning the axe [39-47] (Figure 6.61). However, the rotation of the blank appears to change from clockwise to predominantly anticlockwise throughout this last part of the sequence.

Refitting sequence F

Sequence F totalled 43 flakes, along with the associated ovate handaxe #15. The raw material was a cream coloured flint with white, blue and brown striations throughout. As with sequence A, issues with the adhesive used meant that a photographic record could not be established. The initial removal is missing. It is possible that this may have been used to produce a second handaxe. The knapper then proceeds to remove a further six flakes, all along the same edge of the blank [2-7]. There are several instances of multiple hammer blows needed to remove flakes within this group. A number of the flakes have also shattered due to the force of the hammer blow. The knapper then flips the block over to begin reduction of the other face.

The first few removals [8-18] show the knapper attempting to reduce the raw material, but meeting resistance in the form of internal fractures causing flakes to shatter and step fracture. However, the knapper is able to work around these, rotating predominantly anticlockwise. Platform preparation is seen on many of these flakes. The knapper then switches to the edge opposite the last removal and begins to work this edge, rotating anticlockwise again [19-22]. These flakes terminate at a flaw in the material, with #21 being used to try and remove this. The knapper continues working round the blank, focusing on removing flaws in the flint. Platform preparation continues to be visible on these flakes [23-31]. They then switch to thin the other face of the blank.

The knapper now proceeds to this face, changing from anticlockwise to mainly clockwise rotation of the blank, occasionally alternating direction to thin some sections further [32-43]. Towards the end of this group, the sequence is difficult to establish, due to the fact that many of the final thinning flakes could not be refitted as they were to small and fragmentary. However, it is worth noting that the scar patterns shows the knapper's attempts to thin the area where the artefact number is written, approaching from various angles, all of which ended in step or hinge fractures. Eventually, being unsuccessful, the knapper appears to have given up on their attempts. This may present an idiosyncrasy that may be worth investigating further.

Refitting sequence G

The associated handaxe (#10) for sequence G is an elongated ovate. The raw material used is a black flint with grey patination and a thin iron stained cortex. The sequence is made up of a total of 54 flakes. The nodule is missing two removals across the bottom and top, opening up platforms of flaking at both ends. Two other flakes are missing from the side of the nodule, which were probably for preparation, but determining their removal in terms of the remaining flakes is not possible.

The knapper begins by using the platform created through the initial removal at the top of the nodule, and works anticlockwise around this removing several large flakes [1-10] (Figure 6.62 and 6.63). Following this, they then work back clockwise [11-13], before removing another large flake [14] and several blade like removals [15-16] (Figure 6.64-6.66). These flakes do not display platform preparation, and are relatively clean removals, with only one [11] producing a hinge fracture, which is neatly rectified. One further flake is removed before the blank is turned over.

The right side of the nodule is now thinned, rotating it mainly anticlockwise [18-24] (Figures 6.67 and 6.68). The knapper then moves to the bottom of the nodule and proceeds to reduce this area, again from the right side, this time, alternating between clockwise and anticlockwise rotations [25-32] (Figure 6.68 and 6.69). The blank is then turned over once more, and begins thinning this side, turning the blank predominantly anticlockwise as they do so [33-42]

(Figure 6.70). Here, platform preparation is common and the flakes are much thinner.

The knapper then returns to the other face, rotating the blank clockwise and removing thinning flakes that, again, show a predominance of platform preparation [43-47] (Figure 6.71 and 6.72). A single flake is then removed from the other face [48], before the final thinning is carried out [49-54] (Figures 6.72 and 6.73). As with other sequences, these last flakes are difficult to place correctly within the series of removals, due to the fact that intermediate flakes are often missing, presumably too broken to identify. This indicates a potential issue that may arise in the analysis of archaeological assemblages; especially as such sequences are rarely complete. As a result, flakes missing from the sequence may impede the accurate interpretation of archaeological refitting assemblages.

Refitting sequence H

Sequence H has the second largest refitting sequence, with a total of 59 flakes. The handaxe associated with this sequence is #16. The raw material used in its production is a triangular block of grey, patinated flint with a thick chalk cortex and chalk inclusions within the flint. This thick cortex presented problems for the adhesive used. As a result, a photographic record of this sequence could not be produced. The group appears to be mostly complete, although some flakes are missing. The knapper begins by removing a large, cortical, fan-shaped flake from the base of the triangular block and then works by turning the block anticlockwise, removing two more thick cortical flakes [1-3]. They then turn the block over removing two further cortical flakes. All of these show clear signs of hard hammer technique [4-5].

The knapper returns to the other face of the block, and removes two further cortical flakes from the same area [6-7], before switching back to the previous face. They now use the previous removals as a platform and remove the entirety of the back end of the nodule [8]. The fracture pattern of this flake is complex, with many step fractures on the ventral surface caused by internal flaws and chalk inclusions. The knapper then proceeds to remove a remaining protrusion from the bottom of the triangular nodule [9-11]. The knapper then focuses on reducing one side of the nodule, where the edge protrudes allowing natural platforms to be used. Rotating clockwise, they remove five flakes [12-16]. They then move to the other side of this face, removing a further two flakes, again rotating clockwise [17-18].

The knapper then switches to the other face and removes a flake from the bottom corners of the triangular block [19-20]. This is to create new platforms. They then return to the previous face and removes a large chalk inclusion from the surface [21]. Turning the block over again, the knapper begins to reduce the other face, beginning with a large hard hammer removal [22], and proceeding from this while rotating the raw material predominantly clockwise [23-29]. Following the last of these flakes, the knapper rotates the block through 180 degrees, removing a large flake that terminates at a hinge fracture [30], but also causes a secondary fracture, suggesting that the force of the blow continued. From this point, the knapper produces thinner flakes, with some signs of preparation that appear to be concerned with neatening the handaxe blank [31-33]. While removing these, the knapper rotates the block anticlockwise.

The knapper then proceeds to alternate flaking between the two faces of the block, first removing a flake from one face to produce a platform, before returning to the opposite face [34-38]. After this sequence a further three flakes are removed, continuing to rotate anticlockwise [39-41]. The block is then turned again, and reduction continues, though the direction of rotation changes to clockwise [42-45], before turning the block over once more, and continuing to rotate in the same direction [46-52]. The knapper then removes four flakes from the previous face [53-56], before the final three flakes are removed [57-59]. Again, the rotation is predominantly clockwise. It is worth noting that these final thinning flakes show an absence of platform preparation in most cases, though this does not appear to have hampered the knappers reduction strategy. The raw material appears to have had a direct influence over the knapper, with flaws and inclusions causing various failed terminations, resulting in the knapper having to adjust their strategy to accommodate them.

Refitting sequence I

Sequence I had the lowest number of refitting flakes out of the replica sample, with only 21 flakes refitted to the associated handaxe (#19). The main factor contributing to the lack of refits was the fragmentary nature of the débitage, which meant that establishing the reduction sequence was difficult. The raw material used was a black flint with a thin yellow cortex, with the handaxe produced on a large flake, rather than a complete nodule.

Initial flaking begins on the ventral surface of the flake, thinning the bulb of percussion whilst rotating the flake anticlockwise [1-6] (Figures 6.74-6.76). The knapper then moves to the right margin and begins to thin the tip of the flake [7-8], before returning to the bulb of percussion. From here, they work around the edge of the flake, rotating clockwise [8-12] (Figure 6.77). There are several removals missing from the sequence, though the flake scars on the surface of the handaxe appear to confirm the knappers actions.

The flake is then turned over. Again, many flakes are missing from the sequence. From those that have been refitted, the knapper begins knapping the dorsal surface from the tip of the flake [13]. Knapping proceeds with generally anticlockwise rotation of the flake, though this is interspersed throughout with alternating rotation as the knapper returns to thin an area [14-21] (Figures 6.78-6.80). Platform preparation is evident throughout the sequence, with a higher level of preparation seen compared to the other refitting groups. In addition, the handaxe itself appears heavily overworked compared to the others. However, the most important point is the fact that many of the flakes could not be refitted, meaning that the interpretation of this sequence may be significantly flawed.

ANALYSIS OF THE REPLICA ASSEMBLAGE

Following reconstruction of the sampled débitage, the methodology described in Chapter 3 was applied to the data gathered from the refitting groups (see Table 6.1). The individual counts for each variable were first converted to percentage values in order to standardise the data. The data was then explored using the SPSS statistics package for Windows (SPSS 17, release 17.0.0).

Principal component analysis

Principal component analysis was performed using the SPSS program FACTOR, with no rotation applied to the data. The results of this analysis are presented in Table 6.2. Three components with eigenvalues of greater than 1.0 were extracted from the eight variables, which accounted for 82.8% of the total variation within the sample:

- The first of these components is formed from variation in the amount of flake fragmentation, platform preparation and anticlockwise rotation. This is to be expected, given the larger variation within these variables seen in Table 6.1.
- The second component represents variation in unknown rotations and the number of missing platforms within the sequence.
- The third and final component is also derived from variation in the amount of fragmentation of flakes, in addition to the amount of hinge and step fractures seen.

From these components it is clear that the majority of the variation within the sample of refitting sequences is representative of the amount of platform preparation the knapper used, and the way in which the knapper rotated the nodule whilst shaping the tool.

The results of the principal component analysis were then plotted using scatter diagrams in order to establish potential clusters (see Figure 6.81a-c). When reviewed, it became apparent that those graphs containing component one produced more defined clusters compared to the others. In addition, it was noted that the strong presence of the fractured flake variable within component three repeats what is seen in component one. Therefore, it was decided that a comparison of components one and two would be used to investigate the potential for the analysis to cluster the refitting groups according to their associated knappers.

Cluster analysis

Cluster analysis was then performed on the principal component data, using the SPSS program HEIRARCHICAL CLUSTER. The aim of this program was to divide the refitting sequences into distinct clusters. The results produced a variety of different clusters; with one extreme being that all the refitting groups are the product of one individual, while the other suggests that they are the product of separate individuals (see Table 6.3). From these results, it is suggested that only the analyses that produced three, four and five separate clusters can be deemed accurate. These data were then plotted onto scatter diagrams using the principal components results (see Figure 6.82a-c). The graphs were then compared to those produced previously.

The comparison of the graphs shows that the plot of four clusters conforms exactly to that seen in Figure 6.81a, while the others present noticeable differences. Therefore, these four clusters were put forward as the most probable division of the refitting groups. This was then compared to the undisclosed information regarding the known values of which knapper had created which sequence. These values were plotted onto the principal component data for comparison, as seen is Figure 6.83. Immediately, there are differences between the graphs. The first is that the refitting groups are the product of three, rather than four knappers. The second is that the clusters suggested by the statistical analysis do not conform to those presented by the known data.

Results and reflections

At first this result suggests that the technique is flawed, but closer inspection shows that some of the refitting groups are clustered correctly. Sequences E and H were grouped correctly, as were B and F, although three other sequences were clustered with these. In addition, the analysis producing five clusters indicates that sequences A and C do not cluster with B and F. The cluster analysis also differentiated between sequences G, produced by Knapper 4, and I, produced by Knapper 5. However, the analysis was unable to correctly group these sequences with other refitting material produced by the same knapper. It therefore appears that the methodology was able to divide the sequences into groups that reflected the knappers who made them to a certain extent, but this is distorted in some way. This may be due to factors such as raw material size, shape and quality, which may directly affect the knapper's choice of reduction strategy, thus masking their idiosyncratic imprint upon the refitting débitage.

The question that needs to be answered is why the methodology was unable to correctly attribute the refitting sequences to their respective knappers. In addition, the source of the variation that masks the individual's imprint must also be addressed. To do this, we must return to the refitting sequences. Reflecting upon the process in this manner is critical to the identification of possible reasons behind the techniques failure. Therefore, it is necessary to review those sequences that were not correctly attributed.

Knapper 5: Sequences A, D and I

None of the sequences produced by Knapper 5 clustered together. Only sequence I was grouped separately, but as a significant outlier, rather than as part of a cluster. However, sequence I has the lowest total number of flakes, which may have resulted in the data being skewed once converted into percentage values. It also contains the highest proportion of fragmented flakes, possibly due to the fact that the handaxe was produced from a large flake (see Figure 6.84), meaning that the flakes produced were much thinner and more fragile than those of the other sequences. The sequence also progressed directly to thinning, with no apparent hard hammer technique seen besides the initial removal of the flake blank itself, resulting in a lower number of refitting flakes produced. The highly fragmentary nature of the débitage also severely hampered complete refitting, meaning that the overall interpretation may be flawed due to missing flakes, though care was taken to use scar patterns from missing removals to aid in this task.

Sequence D is also important, due to the fact that is was provided without an associated handaxe. It also has a high degree of fragmented flakes, but does not cluster with sequence I. The reason for this is likely to be a result of issues in refitting. The lack of an associated handaxe resulted in the sequence being refitted in a series of sections that could not be related to one another. It is suspected that this had severe implications for the interpretation of the way in which the nodule was manipulated by the knapper, which, therefore, influenced the results that were obtained.

Sequence A provided an almost complete sequence, which could be followed in detail, although there is the possibility that the order of the earlier removals may present issues. The knapper appears to use anticlockwise rotations to a similar degree to those other sequences that A is clustered with. However, it does show the lowest amount of clockwise rotations, but not to a great degree.

Finally, Knapper 5 was revealed to be the only left handed knapper present in the replica assemblage. It is possible that this may have influenced the reduction strategy in some way. However, the fact that sequence D clusters with those of the other knappers, suggests the preference of left or right hand for knapping does not affect any idiosyncratic imprint that may be found within the variables studied here.

Knapper 1: Sequences B, F and G

Sequence G was the only one attributed to Knapper 1 that did not cluster. The tool produced (handaxe #10) was an elongated ovate formed from a lenticular nodule (see Figure 6.85). It is suspected that this shape had a direct impact upon the reduction strategy applied, given that the initial flaking is approached from the top and bottom, as opposed to the sides of the nodule. Therefore, the knapper was forced to accommodate the raw material in order to achieve their goal.

Sequences F and B, while differing substantially in terms of the amount of flawed terminations and platform preparation, are very similar when the amount of fractured flakes and the direction of rotation is compared. This suggests that these variables may be of more value when looking for idiosyncrasies that can be tied to the individual. However, as the amount of fracture flakes may equate to skill, raw material quality or assemblage disturbance, this variable may not be as useful in representing idiosyncrasies accurately. Finally, Sequence G differs greatly in respect to these variables, which resulted in it not clustering correctly.

Knapper 4: Sequences C, E and H

Returning to the record from sequence C, which did not cluster with the rest of Knapper 4's sequences, what stands out the most is the high frequency of unknown rotations. These were almost double those recorded for sequences E and H. It is important to note here that the raw material use to produced sequence C and its associated handaxe (#21) was a globular form (see Figure 6.86). This caused the knapper to move large distances around the circumference of the nodule in order to shape the blank from which the tool was produced. Due to these large rotations, it was almost impossible to correctly identify whether the direction was clockwise or anticlockwise with any degree of accuracy. As a result, it appears that the raw material form constrained the knapper's choice of reduction technique in the initial phases, forcing them to remove various protrusions before the nodule could be shaped and thinned.

Sequences E and H, similar to B and F above, differ the most between the numbers of flawed terminations, with sequence E having over twice as many as H. However, as noted above, these variables do not play as great a role in components one and two, and therefore do not influence the interpretation of these results as much. More importantly, perhaps, is the fact that sequence H shows a higher degree of same location removals that E. Looking back at the description of the knapping process, it is clear that sequence H, made on a triangular block of flint, displays removals that often use the same platform because the knapper was attempting to considerably reduce sections of the raw material. It is possible that this was caused by the shape of the flint block itself, which adds further weight to the proposal that it is raw material constraints that are constraining the individual's idiosyncrasies in the reduction process and making it difficult to locate the knapper's imprint.

Summary

After reflecting upon the sequences studied, it can clearly be seen that any individual imprint that could be used to directly attribute the refitting débitage to the knappers is masked by a combination of factors. Primarily, this appears to be the result of elements within the raw material used, especially the shape of the nodule selected, which may constrict the knapper and force them to adopt alternate reductions strategies from one that they might ordinarily use. In addition, the inability to reconstruct full refitting sequences, as displayed by D and I, has a strong effect on the results obtained during the analysis. The handedness of the knapper may also present problems, though this is open to debate given that more than half of Knapper 5's products also clustered with those of Knappers 1 and 4.

It may be possible to circumvent some of these issues by studying only those flakes that are produced in the thinning stages of handaxe manufacture. This stage has been suggested to contain approximately 50% of the total knapping sequence (Bradley & Sampson 1986: 36-37). In addition, dividing the samples according to the raw material used, whether nodule or flake, may also prove helpful, as well as being able to assess handedness. Finally, the use of sequences that are as complete as possible would be preferable, so that the samples can be adequately compared. However, it is important to note that such demands have heavy implications for the applicability of this method of analysis to the archaeology, where complete refitting sequences are lacking in most circumstances and thinning flakes can be especially absent. In addition, the variable nature of the archaeological record means that it is sometimes impossible to determine whether a tool was produced from a flake or nodule due to the absence of vital refitting material. Therefore, while these demands may strengthen the utility of the methodology for a sample of replica artefacts, it may prove to strenuous for the production of informative results from the Lower Palaeolithic record.

THE ARCHAEOLOGICAL ASSEMBLAGES

Although the methodology has been shown to be inadequate at attributing the refitting sequences from an experimental sample, it is still necessary to investigate archaeological assemblages. While is it currently still impossible to show which handaxe has been created by which knapper, a study of archaeological material will highlight differences and similarities between it and the replica assemblage. This is important as it will either emphasise or refute the commonly held concept that replication of the knapping techniques used to produce tools is not necessarily the same as recreating a prehistoric technology (Dobres 2000). It will also highlight problems with the use of replica assemblages that will need to be addressed in future research.

As a result, two assemblages of archaeological refitting material were studied. These were the refitting débitage from GTP17 at Boxgrove, West Sussex, and the Cottages Site at Caddington, Bedfordshire. Each refitting sequence was studied in a similar manner to those of the replica assemblage. However, all of the sequences studied had been reconstructed using permanent adhesive. Therefore, the sequences could not be deconstructed in the same manner as the replica assemblage, where a non-permanent adhesive was used. Although it was possible to review most of the flakes in these refitting sequences, it is highly probable that some of the interpretations may not be as accurate as possible given that the sequence could not be fully studied in terms of the exact methods the knapper used. The refitting sequences will now be discussed below.

BOXGROVE, WEST SUSSEX

A total of five refitting sequences from Boxgrove were studied. All of these came from the GTP17 site in Quarry 2. The longest sequence consists of a total of nineteen flakes, while the shortest has just six. No associated handaxe is provided for any of the sequences. A description of each sequence was recorded and the knapping procedure is outline below. Each of the sequences has been named based on those provided in Pope's (2002) analysis of this material. The data recorded for each of the refitting sequences is displayed in Table 6.4.

Group 1

This sequence of thirteen refitting flakes represents one half of a nodule, from which an ovate handaxe was removed (Figure 6.87). The raw material is a grey-black flint, with yellow and olive colouring. The cortex is white and relatively thick. It appears as though the knapper initially approached one side before attempting the other. The first removal in the sequence is a large hard hammer flake, which shows evidence of three to four flakes removed before it. A second large hard hammer flake is removed after rotating the nodule clockwise. The knapper follows this by rotating the nodule 90º anticlockwise to remove a third large flake. They then work along the edge, rotating clockwise and back towards the first removal [4-5] (Figure 6.88).

The knapper now rotates to the other side of the nodule. From here a very large flake is removed, leaving a large straight platform for future flaking [6]. Using this platform, the knapper removes a large elongated flake that displays a cortical dorsal surface with three protuberances [7]. It appears that this flake was designed to rid the surface of the nodule of these before further flaking took place. The next flake was removed by rotating the nodule anticlockwise [8]. This flake is much shorted than the others, but retains the width of previous flakes. The following two flakes [9-10] were removed by rotating back clockwise (Figure 6.89). The dorsal surface of flake #9 shows at least two flakes are missing from the sequence. This flake also shows signs of preparation, though it terminates at a large hinge fracture. It is probable that the knapper was attempting to remove a ridge in the material. Flake #10 also terminates at a hinge fracture, which would have left a large, deep negative scar.

The knapper then rotates 180º and removes another two flakes (Figure 6.88). These may have originally been one flake that split due to the impact of the hammer stone. The tip shows the hinge fracture scars from flake #9, and therefore partially corrects this mistake. The knapper then rotates the nodule anticlockwise before removing the final flake.

Group 4

Group four was the shortest sequence, with only six flakes (Figure 6.90). These six flakes have been refitted from a total of 11 fragments. The raw material used was a grey and yellow flint, with brown mottled patination, similar to that found in other flake samples found in the same area of the site. The sequence appears to represent from the thinning of a previously prepared roughout. Only one face is represented, which indicates the production of an ovate tool approximately 15cm in diameter.

The sequence shows that the knapper was aiming to thin the area. The first flake is a smaller thinning flake, showing platform preparation and a fracture across the middle. This is followed by a second removal directly below, which has also fractured. Rotating the blank clockwise, a more substantial flake is removed that projects across the middle removing a large ridge. Again it is prepared and fractured. The fourth flake is removed from directly opposite the previous removal. The goal of this flake appears to be attempting to thin the ridge in the middle of the blank further, though it does not manage to do so. Rotating clockwise, a long flake is then removed, which has fractured into three pieces. Flake scars on the dorsal surface suggest a missing removal between flakes three and four. The last removal is a small triangular flake removed by rotating anticlockwise. The butt of the flake is absent and there are signs of fracture. The sequence then ends, though it is obviously not complete in terms of the overall reduction of the blank. What it shows though is that the knapper has a clear goal, which is to thin the blank, and they are able to achieve this with reasonable skill. It must also be noted that the degree of fracture may be due to post depositional processes, but given the primary context conditions of the site it is possible that these breaks may be directly related to the knapping procedure.

Group 9

This sequence is made up of eighteen visible flakes (Figure 6.91 and 6.92). It consists of mainly cortical hard hammer flakes, produced on a grey-black flint with grey inclusions. The cortex is thin, with a blue-white colour. The sequence indicates that there were some previous removals and that the nodule had been considerably thinned on one side prior to being brought to the site (Pope 2002: 144).

The knapper begins the sequence by removing a protrusion from the surface of the nodule. The next four flakes are all removed from the same area, with the knapper alternating between clockwise and anticlockwise rotation of the nodule [2-5]. Several of these flakes show evidence of missing removals in the scars on the dorsal surfaces. Unfortunately it was not possible to accurately determine the rotation of the nodule for these removals.

The knapper then rotates the nodule through 180° and begins to thin the surface. There is possible platform preparation seen on this flake. The knapper then works around this edge, alternating between anticlockwise and clockwise rotation [8-12]. It appears that when the knapper reverses the rotation he revisits an area to ensure a level degree of thinning across the surface. The final six removals continue to follow this pattern of rotation, with flakes showing some platform preparation. While many of the flakes do not fully extend over the face of the nodule, what has been noted is that the reduction produced an "elegant convexity" to the blank being produced (*ibid*.: 147).

Group 19

Group 19 displays another cortical reduction sequence. It consists of nineteen refitting flakes and was produced from a grey flint that grades to olive green in places (Figure 6.93 and 6.94). Lighter grey inclusions are seen throughout. The cortex where present is thick and cream coloured. Several other artefacts produced on similar raw material were also excavated at the site (Pope 2002: 147).

From the scar patterns present on the flakes, it appears that two flakes removed prior to those studied are missing. The first flake refitted to the sequence is a long thinning flake. A second flake is removed slightly clockwise of this, before the knapper rotates the nodule anticlockwise to remove a flake. Knapping then proceeds by rotating in a clockwise direction [4-8]. These flakes vary in size and several are missing sections, especially the butt. The knapper then removes a flake with no visible rotation [9], before continuing to rotate the nodule clockwise [10-13]. The knapper then begins to work back across this edge, rotating anticlockwise and producing several smaller chips [14 and 16] and two larger flakes [15 and 17]. The nodule is then rotated anticlockwise by 90° to remove an extended flake that passes over the middle of the blank being produced [18], before a final small flake is removed [19]. Following this the nodule would have needed further thinning to remove instances of high platform angles before a blank suitable for handaxe production could be achieved. However, the rest of the sequence is missing and must have been removed from the site.

Group 53

This sequence is formed from a total of ten flakes (Figure 6.95 and 6.96). It was made from a yellowish flint with a white cortex. The sequence shows elements of initial decortication leading up to the primary thinning of the handaxe blank. The initial removal in the sequence is designed to remove a protrusion from the nodule. There are some scars on the dorsal surface of this flake, showing that previous flakes have been removed. Also, the platform use has been formed from a previous flake removal. The technique used is clearly hard hammer, given the fact that the butt has partially shattered and the point of impact can be seen on the platform. The knapper then rotates through 180º to remove the second flake, which is again removed using hard hammer technique. The dorsal surface also shows that at least five flakes were removed prior to it. A third, much larger flake is then removed, rotating anticlockwise.

From here the knapper works by rotating the nodule clockwise, to removed the next to flakes [4-5]. These also show evidence of being hard hammer flakes and the dorsal surfaces also indicate flakes that are missing from the sequence. Then the nodule was rotated 90º anticlockwise and a highly fractured flake was knapped [6]. This flake split into two halves along the vertical axis and also appears to missing the butt portion. A further flake was removed from directly below it [7], but only the tip of this flake has been refitted.

The next flake is larger and was knapped [8] after rotating the nodule anticlockwise from the previous removal. This flake is also fractured, though the termination is feathered, similar to the other flakes studied. Another fragmented flake was removed below this [9], before the final refitting flake of the sequence was knapper, rotating the nodule anticlockwise to access it. This final flake has also split across the middle. It is proposed that quartz flaws in the flint may have caused this.

ANALYSIS OF THE BOXGROVE ASSEMBLAGE

Once the data had been recorded for the five refitting sequences from Boxgrove, the methodology was applied as per the replica assemblage. Again, the counts for each variable were converted to percentages in order to standardise the data, which was then explored using principal component and cluster analysis within SPSS. The results of these analyses and a comparison with the results from the replica assemblage now follow.

Principal Component Analysis

The principal components for the Boxgrove assemblage were extracted from the data using the FACTOR program within the SPSS software package in the same manner as for the replica assemblage. No rotation was applied to the data. From the eight variables studied, a total of four components were extracted with eigenvalues greater than 1, which account for 100% of the variation in the sample (see Table 6.5):

- The first of these components is comprised mainly of the variation in the number of fragmented flakes and flakes with missing butts, followed by platform preparation and removals from the same location.
- The second component accounts for the variation in unknown rotations, while the third component shows variation in hinge and step fractures.
- The final component is comprises the variation in anticlockwise and unknown removals.

The results of the analysis reflect the high degree of variation in fragmentation of the refitted flakes found at Boxgrove. This may be indicative of the degree of skill with which the knappers approached the reduction strategy, or may be attributed to variation in the strength of the hammer blows within each sequence, which may also be linked to the knapper's idiosyncrasies. Finally, the level of fragmentation could be a result of the raw materials chosen by the knappers. It is unlikely that the levels of fragmentation can be attributed to post depositional processes, given that the GTP17 site shows little evidence of trampling structures and artefact movement beyond low-level size sorting (Pope 2002: 112). In addition, the artefacts remain sharp and unrolled. However, given that the results of the replica assemblage were unable to attribute refitting sequences to the knappers that created them, it is not currently possible to provide a conclusive interpretation of this variation.

The high variation in the amount of flakes missing butts and the platform preparation seen are both linked, in part, to the variation in flake fragmentation. In addition, the amount of platform preparation seen tends to increase as reduction progresses. Therefore, those sequences that only contain cortical removals and initial blank shaping, such as Group 53, show much lower levels of platform preparation when compared to extended sequences that include thinning flakes.

The variation in the amount of removals from the same location appears to have been introduced by Group 19, which has almost double the frequency of these removals compared to the next highest. Returning to the refitting sequence itself, the high number of flakes removed directly below one another is a result the reduction of a cortical flint nodule with several protrusions. Therefore, the knapper appears to focus on the reduction of these areas prior to thinning the handaxe blank.

The variation in unknown rotations displayed by the second component can be readily attributed to the fact that many of the sequences are missing flakes, which increases the difficulty in ascertaining the rotation of the flint nodule as each flake is removed. In addition, the fact that the sequences primarily display initial decortication, rather than thinning and finishing, means that the knapper is shaping the nodule into a blank, as opposed to carrying out a uniform method of reduction. In this way, the knapper aims to trim protrusions and remove cortex from the nodule, as well as establishing platforms for further flaking, prior to producing the actual handaxe itself. Therefore, the knapper is more likely to switch from one area of the nodule to another during this stage, rather than carrying out continuous flaking along an edge.

The variation within the final two components is also addressed. The variation in flakes with flawed terminations may be a direct result of skill. In addition, this may have a greater ability to indicate variation in knapping idiosyncrasies, given that the raw material available to the knappers at Boxgrove is broadly similar. Finally, although variation in clockwise rotation is part of the fourth component, the data shows that this is relatively small. It appears that the knappers at Boxgrove rotated nodules mainly clockwise, introducing variations in the rotational schema in order to address issues in the raw material, shaping of the handaxe blank, or thinning of the tool. However, it must be noted that the sequences studied were incomplete and, therefore, no conclusive information regarding the knappers predilection for the direction of rotation can truly be ascertained.

Comparison to the Replica Assemblage

The results of the principal component analysis were also compared to those of the replica assemblage. At first, the two appear relatively similar, though there are some subtle differences. The first component is very similar, though the level of variation introduced by the number of fractured flakes and missing butts is much greater in the Boxgrove sample. However, the main difference is in the rotation, with the replica sample showing large variation in anticlockwise rotations, compared to the variation in same location removals seen at Boxgrove. As mentioned above, this is likely to have been introduced due to the fact that the Boxgrove samples are mainly representative of initial decortication and the removal of protrusions from the raw material.

The second and third components are also similar, with the only differences being that the second component from the Boxgrove sample lacks any input from the missing butts variable, while component three displays only the variation in flawed terminations. The addition of a fourth component in the Boxgrove sample is also different, with the variation in clockwise rotation within this component not seen in the analysis of the replica sample.

Though there are differences between the two samples, it is interesting to note that the major source of variation is within the amount of platform preparation that the knapper applied and the way that the nodule was rotated during reduction. However, rather than being explicitly indicative of idiosyncrasies on the part of the knappers themselves, the composition of the sample from Boxgrove suggests that this variation stems from the stage of the reduction sequence studied, as well as the form of the nodule that was chosen.

Cluster Analysis

Cluster analysis was also conducted on the Boxgrove sample, using the data produced from the principal component analysis. Clustering was achieved through the use of the HIERARCHICAL CLUSTER program within the SPSS software package. The results of this analysis are displayed in Table 6.6 and were also plotted onto scatter diagrams (see Figure 6.97-6.102). While it is impossible to ascertain whether individual idiosyncrasies can be traced from sequence to sequence, given the failure of the methodology to do so in the case of the replica sample, it was deemed valuable to provide a comparison between the clusters produced within the Boxgrove sample and those of the replica assemblage.

It is interesting to note that the majority of the scatter diagrams show that the relationships produced by the cluster analysis do not indicate clustering of adjacent refitting sequences as expected, but instead display much broader clusters. The graphs that contain component three, however, show tighter clusters, with the tightest groupings being in Figures 6.100a-c. What the scatter diagrams then suggest is that, within the Boxgrove sample, components two and three have a greater affect on the cluster analysis.

In comparison to the results from the replica assemblage, Boxgrove presents an interesting disparity. Where the clustering analysis for the replica assemblage suggests that the variability within fragmentation, platform preparation and direction of rotation can be used to separate the refitting sequences into groups, the results of the Boxgrove analysis indicate that the level of flawed terminations and unknown rotations play a larger part in the distribution of the clusters. This serves to highlight that there are subtle differences between the replica and archaeological samples. The question is what causes these differences.

Returning to the data from Boxgrove, it is clear that the variation in the amount of unknown rotations is linked to the size of the refitting sequence studied. Sequences with a greater number of flakes allow the direction of rotation to be followed with greater ease, while those with limited numbers of flakes are often more complex to interpret accurately. In addition, as mentioned above, it is highly likely that this variable is influenced by the stage of reduction being studied. In the case of the Boxgrove sample, all the sequences came from initial decortication and shaping stages, where the rotation of the nodule appears to occur in an unsystematic manner. In contrast, the replica refitting sequences were, for the most part, complete.

Perhaps more interesting is the fact that component three factors into the cluster analysis conducted on the Boxgrove material to a greater extent than with the replica sample. In both cases the variability in flawed terminations heavily loads this component. In the replica sample flawed terminations, such as hinge and step fractures, can be either explained by the knapper's skill or the occurrence of inclusions within the raw material that redirect the force of the hammer blow, causing the removal to terminate early. At Boxgrove there is a similar situation. Revisiting the descriptions of the refitting on a flake-by-flake basis, the two sequences that show the highest amounts of flawed terminations are Group 1 and Group 53. Of these two groups, the description of Group 1 suggests that the majority of flawed terminations occurred during an attempt to remove a ridge in the surface of the nodule. The knapper was finally able to remove this through a large flake removal from the opposite side of the nodule, but it is worth noting that the first few attempts failed. With Group 53, the occurrence of flawed terminations appears to be due to the presence of quartzite inclusions within the flint, indicating that the raw material was directly responsible for the early termination of these flakes. However, both of these groups have limited numbers of flakes, especially when compared to the replica sample, and it is certainly possible that with further refitting flake these sequences could display contrasting data.

Summary

While the principal component analysis of the data recorded from the Boxgrove refitting sequences is comparable to that of the replica assemblage, there are subtle differences that indicate the possibility of contrasting knapping procedures, as well as differing approaches to raw material properties. In addition, cluster analysis of the data does not produce tight clusters of refitting sequences that may be used to trace idiosyncrasies between the sequences studied. This is contrary to what was expected.

While there appears to be a common and sustained preference for clockwise rotation of the nodule during knapping, it appears that actions outside of this rotational schema, although the result of the knappers' choices in the pursuit of their goals, are governed by factors other than individual idiosyncrasies. It is suggested that chief amongst these factor are the properties of the raw material being used. In addition, the fact that the refitting sequences from Boxgrove were not complete is likely to have had an effect on the results, especially given that the majority of the sequences studied displayed initial decortication. As was noted in the discussion of the replica sample, the initial stages of reduction focus on shaping the nodule into a workable blank. During this process the knapper is less likely to adhere to a strict reduction strategy, but will be more flexible, aiming to remove immediate obstacles and produce platforms sufficient for the initial thinning of the handaxe blank. It has already been suggested that focusing on the thinning and finishing stages of handaxe production may be more revealing where we are concerned with tracing a knapper's idiosyncrasies from one sequence to another. However, the archaeological record from Boxgrove clearly shows that the majority of refitting flakes are more likely to come from earlier stages of reduction, which are influenced to a greater extent by the nodule that the knapper chooses. It therefore appears that the refitting sequences from Boxgrove are telling us more about the raw material's affect upon the knapper's choices, rather than displaying specific idiosyncratic actions in the production of a finished handaxe.

CADDINGTON, BEDFORDSHIRE

A total of nineteen groups of refitting flakes from Pit C at Caddington were studied. Of these, three were made up of one or two flakes refitted to a core or handaxe, and one was a sequence of only two flakes. As a result, these sequences were not analysed further. Of the remaining sequences studied, six contain four or fewer flakes. While these were studied further, it is highly likely that such small sequences will produce biased results when compared with more established refitting groups. A description of each of the sequences studied is provided below. Each sequence has been given a number from one through to fifteen. In addition, the catalogue number has also been provided where available (see Table 6.7).

Group 1

Group one is made up of four refitting flakes (Figure 6.103). The raw material is a blue-grey flint with a thin iron stained cortex and olive patination. The sequence shows part of the initial decortication of a nodule. The first flake to be removed has an entirely cortical dorsal surface. However, it does show some signs of platform preparation. The next flake is removed following a clockwise rotation. It is similar to the previous flake, but displays no cortex on the dorsal surface apart from the tip. Fragmentation of the butt prevents any analysis of platform preparation. The nodule is rotated clockwise again prior to the third removal, which also shows signs of preparation. The final flake follows the same pattern of clockwise rotation, though this time the flake split in two. The sequence has no further flakes refitted, though it is obvious that the sequence must have continued.

Group 2

Group 2 consisted of six refitting flakes and their associated handaxe (Figure 6.104 and 6.105). A yellow-grey flint with a thin cream cortex was used to produce this sequence. As this is a partial sequence, many of the flakes are missing, as evidenced by the flake scars on the dorsal surface of the initial removals and the faces of the handaxe. The first removal is the largest flake in the sequence. It has an unprepared platform, instead using a flake scar from a previous removal. The dorsal scarring indicates at least four removals prior to it. The knapper then rotates the nodule anticlockwise to the handaxe tip to remove a small fractured flake with cortex covering the dorsal surface [2]. Continuing to rotate anticlockwise, the next flake is larger and, again, is unprepared [3]. The dorsal scarring shows several prior removals, including one directly below flake #2. The direction of rotation for these flakes appears to be anticlockwise before returning to this flake. However, it is difficult to prove this while the flakes are absent.

The next flake is removed after rotating the nodule clockwise slightly [4]. The butt of this flake is missing and the dorsal surface is cortical. There is also another removal missing below this flake. The knapper then rotates clockwise again to remove the fifth flake [5]. This flake shows little cortex on the dorsal surface and the platform is unprepared. The final flake has been refitted to the other face of the handaxe [6], and therefore the rotation cannot be ascertained. This is a smaller, soft hammer finishing flake across the tip. The dorsal surface indicates at least two prior removals.

Although the refitting ends with this final flake, the dorsal surfaces of the flakes themselves and the axe they are refitted to clearly show that many flakes are missing. These scars also show some large hinge fractures, which may have been caused by knapping mistakes. It is possible that such flaws may have led the handaxe to be discarded before it was fully finished.

Group 3

This group was formed from ten refitting flakes, which were attached to an unfinished handaxe blank (Figure 6.106 and 6.107). The sequence was produced using a grey flint with a relatively thin cortex that is now iron stained. The first removal in the sequence is a large, hard hammer flake. The dorsal surface is cortical and the platform used was produced by a prior removal. There is also a slight step fracture termination seen on the right dorsal edge of the flake. The second flake corrects this. The blank is rotated anticlockwise prior to the knapping event [2]. Again the flake shows a cortical dorsal surface.

The knapper then removes two flakes, rotating clockwise for each [3-4]. The first of these has a cortical platform, while the second shows possible signs of preparation. The nodule is then turned over, and a flake is removed from along the butt of the handaxe [5]. The dorsal surface of this flake shows at least four prior removals and the platform has been prepared. The knapper then returns to the previous side, and removes a flake from below flake #2 [6]. This flake has clear evidence of platform preparation. In addition, the dorsal surface shows that there is a missing flake between #2 and #6. The next flake is removed from below #6 with a slight clockwise rotation [7].

The knapper then rotates the nodule to the opposite edge. The actual rotation is uncertain, but the shortest distance would be by turning the nodule clockwise. The flake removed has a cortical dorsal surface and the platform appears unprepared [8]. In addition, a single flake scar can be seen on the dorsal surface, which indicates a previous removal anticlockwise of #8. This supports the theory that the direction of rotation is clockwise. The next flake [9] is removed by rotating anticlockwise of the previous flake. However, it is probable that many flakes in between are missing. The final refitting flake is removed after rotating anticlockwise [10]. Although this is the last flake to be refitted the scar patterns on the roughout indicate further flakes that are missing. The roughout appears to have been discarded due to an inability to thin it to the correct shape, though the low level of flawed terminations suggests that the knapper was relatively skilled at flint reduction.

Group 4

This group of refitting flakes shows part of the initial decertification of a flint nodule, which was drawn by Smith in his book 'Man the Primeval Savage' (Figure 6.108). It is made up of ten flakes and was produced on a blue grey flint that grades into olive near the cortex, which is cream in colour and relatively thin (Figure 6.109 and 6.110). It should be noted that Worthington Smith refers to eleven flakes in this sequence. It is possible that one piece is hidden under the other visible flakes, or that Smith refers to the broken tip of flake #8. As this eleventh flake could not be seen, it has not been included in the description presented below.

The first removal is a very large hard hammer flake. What is interesting about this flake is that it shows clear signs of subsequent working around the edges, indicating that this may also have been used to create a tool. The next flake is removed from the surface of the initial removal and is much smaller, with signs of previous removals on the dorsal surface [2]. A third flake is also removed from the surface of the initial removal after rotating it clockwise [3]. Again, this flake shows scaring on the dorsal surface that attests to at least six prior removals. It then appears that unifacial reduction continued in a predominantly clockwise direction.

The refitted sequence then continues with the other section of flint. Here a smaller flake is removed, showing at least three prior removals on the dorsal surface, as well as signs of preparation [4]. Rotating the nodule clockwise, another smaller flake is removed, this time with a much larger platform area [5]. This is followed by an anticlockwise rotation to remove a very large hard hammer flake [6]. The knapper continues to rotate anticlockwise, removing a smaller chip [7] and a larger flake with a fractured tip that has also been refitted [8]. It then appears that at least two flakes are missing from the sequence before the next flake. However, it is clear that the knapper continues to rotate the nodule anticlockwise, removing these flakes, before the final two flakes in the sequence [9-10]. The first of these is unprepared, while the second shows evidence of some platform preparation. Though the sequence must then continue, no further refitting flakes have been found.

Group 5

Group 5 consists of eight flakes, which make up part of the decortication of a flint nodule (Figures 6.111-6.113). The raw material is a grey and cream coloured flint, with a thin cortex that has become stained by iron. The sequence is missing several of the initial flakes prior to the first refitted removal, which is the tip of a small flake [1]. The rest of this flake is missing. The following flake is a much larger hard hammer flake, which is removed after rotating the nodule anticlockwise [2]. The nodule is then rotated slightly clockwise. Another larger flake is removed, with the dorsal surface showing clear signs of scarring from previous removals [3]. The knapping now shifts to the opposite side of the nodule. The rotation is unknown, and it is probable that there are several missing flakes between #3 and the next removal. The next flake is fan shaped and missing the butt [4]. The dorsal surface shows signs of at least three prior removals. The nodule is then rotated clockwise for the next flake, which is larger and shows the first evidence of platform preparation [5]. The final three flakes are removed as the knapper rotates the nodule anticlockwise [6-8]. Only one of these, flake #6, displays any evidence of platform preparation. However, all of the final three flakes are large and appear to have been removed using a hard hammer technique. The flakes within the sequence predominantly show evidence of feathered terminations, with only one flake having a hinge fracture termination (flake #8). This may point to a distinct level of control over the raw material by the knapper, though the limited numbers of flakes present means that this cannot be adequately proven.

Group 6

This sequence of refitting flakes contains just four flakes, representing the initial decortication of the raw material (Figure 6.114 and 6.115). The flakes were produced from a grey and cream coloured flint, similar to that used to produce group 5. The first of the flakes is a large hard hammer removal with a cortical dorsal surface. There are no visible signs of platform preparation present. The knapper then rotates 180° to the other side to remove the second flake. Again, this is a large flake with no platform preparation. The dorsal surface also indicates at least two missing flakes were removed prior to it. A third large flake is removed after rotating anticlockwise. The dorsal surface on this flake also suggests that a flake may be missing from the sequence. However, this flake would support the rotation recorded. The final flake is removed after rotating clockwise. All of the flakes show no signs of platform preparation or flawed terminations.

Group 7

This sequence presents another episode of decortication. It is made up of a total of six refitting flakes, produced using a grey flint with a relatively thick cortex (Figure 6.116 and 6.117). The first removal is a large, entirely cortical flake that shows evidence of platform preparation. The nodule is then turned anticlockwise through 90° before removing the second flake. This flake also shows platform preparation, as well as scaring on the dorsal surface that indicates two missing removals between this and the previous flake. The knapper then rotates the nodule clockwise to remove two more flakes [3-4], which show no signs of preparation. The following flake is removed after rotating back anticlockwise [5]. This removal is fragmented and the butt is missing. The final flake is removed after rotating clockwise. Similar to flake #5, this flake also has a fractured butt.

Group 8

Group 8 consists of seven refitting flakes. Once again, this sequence presents a section of decortication from a nodule of grey to blue-grey flint with an iron stained cortex (Figure 6.118 and 6.119). The first two flakes removed appear to form one thick flake, with flake #2 being shatter from the impact of the hammerstone [1-2]. The dorsal surface shows that at least three flakes were removed in the same direction prior to this one. The next flake is removed form the opposite end of the sequence and again shows evidence of flakes missing from the sequence [3]. The knapper follows this by removing a further flake directly below #3, which is much smaller in size than the others [4]. The nodule is then rotated through 180° to access the next flake, which shows signs of fragmentation, especially around the platform [5]. The knapper then works anticlockwise around the nodule to remove the final two flakes in the sequence. The first of these is the only flake in the sequence to show signs of platform preparation. The termination of all of the flakes is feathered, which may indicate a level of skill, though the limited number of flakes precludes any firm conclusions about the knappers abilities.

Group 9

Group 9 is one of the shortest sequences, consisting of only three flakes (Figure 6.120). All of the flakes show no evidence of cortex and all of them display clear indicators of hard hammer technique used to detach them. The flint used is a grey to grey-blue flint, similar to that used to produce group 8. The first flake is removed along the line of a crest in the raw material. There are no visible signs of preparation on the platform of this flake. The knapper then rotates clockwise to remove a second flake with a prepared platform and possible missing pieces that have fractured. The final flake is removed after rotating anticlockwise. The platform on this flake is unprepared and flaws on the ventral surface indicate a large step fracture. Otherwise, all the flakes display feathered terminations.

Group 10

Group 10 is another sequence consisting of three flakes. The raw material is a grey flint with a thick iron stained cortex (Figure 6.121). It appears to represent part of the initial decortication of a flint nodule. The first flake that has been refitted displays two prior removals on the dorsal surface, which is otherwise cortical. The nodule is then rotated anticlockwise and a second flake is removed. This flake shows evidence of a prepared platform, while the tip of the flake is fragmented and is missing. The final flake is removed after rotating the nodule clockwise and is similar to the second flake, with a prepared platform and the very tip of the flake is missing.

Group 11

This group of refits consists of four flakes, again from the initial decortication of a grey flint nodule with a relatively thick white, iron stained cortex (Figure 6.122). The first flake is a thick hard hammer flake, which is missing its tip. The following flake is removed after a clockwise rotation. It is similar to the first flake, with a large flat platform and feathered termination. The third flake is removed directly beneath the previous flakes. It is elongated with a flat butt. One prior removal following flake #2 is missing, but otherwise the dorsal surface shows no other flake scars that indicate further flaking. The last flake is removed following an anticlockwise rotation. It is similar to flake #3, thought the tip shows a lip at the termination.

Group 12

Group 12 is the second longest sequence from the Caddington refitting sample, containing a total of twelve flakes. This sequence was used by Smith to produce a cast resembling the blank contained within (Figure 6.123). The sequence consists of two conjoining sequences that form one side of the nodule (Figure 6.125 and 6.126) and a third sequence that makes up the other face (Figure 6.124). These three sequences can all be connected together.

The first flake is large, fan shaped and cortical. The dorsal surface displays a single flake scar, showing a small removal prior to this flake. The knapper then rotates the nodule anticlockwise and removes the next flake {2]. This is also another cortical flake. The platforms on both these flakes show no preparation, but do suggest that multiple blows were needed to detach these flakes. The knapper continues by rotating anticlockwise again, and removing a similar flake to #2, which has some cortex on the dorsal surface, but indicates no missing flakes [3].

The knapper then flips the nodule. It must be noted that there is a large proportion of flakes missing from this face of the sequence prior to the extant refits. The first refitted flake [4] is removed from the opposite side of the nodule when compared with flake #3. The dorsal surface shows a hinge fracture scar that indicates a flake was removed from opposite it. The platform is cortical. The knapper then rotates clockwise and removes a thick flake with an unprepared platform [5]. The next flake could have been removed at the same time as #5, or, alternatively, it may have been knapped from the opposite edge of the nodule [6]. However, the ripple marks on the ventral surface follow the direction of the force used to remove flake #5. Therefore, it is probable that this flake was detached as a consequence of removing the previous flake.

The knapper then rotates to the opposite side of the nodule, though the exact direction of rotation cannot be ascertained. The flake removed is missing its butt, which has snapped along the horizontal axis [7]. A similar flake removed from below [8]. Again, the butt of the flake is missing. Once these flakes have been removed, the knapper begins to work around the edge of the nodule. The first of these is removed below the two previous flakes and is much larger with a cortical platform [9]. The knapper then continues working along the edge removing the last three flakes [10-12], rotating the nodule anticlockwise. These three flakes are also large with unprepared platforms. All of these flakes also show signs of extensive flaking that has not been refitted to the sequence.

Although the sequence is missing a large number of flakes, there is a preference for anticlockwise rotation in areas. There is also some evidence of skill, indicated by the correction of the hinge fracture removed by flake #4.

Group 13

This sequence consists of two large hard hammer flakes and one smaller flint spall from the initial decortication of a flint nodule (Figure 6.127). The first flake is missing its butt and displays three scars on the dorsal surface, the result of several previous removals that have not been refitted. In addition, the tip has snapped along the horizontal axis. The nodule is then rotated clockwise and a small spall is detached with evidence of some platform preparation. It is possible that this flake was removed in an attempt to detach the final refitted flake, which has been removed directly below. This final flake is similar in size to the first flake and shows evidence of platform preparation. It also appears to have fractured across the middle. The sequence may indicate that the knapper was unskilled at preparation, as the evidence displays a number of small hinge fractures, though it is possible that the cortex interfered with the flaking process. The fact that the knapper was able to correct the removal of flake #2 also suggests that some skill was involved. However, the lack of any further flakes refitted to this sequence means that the knapper's skill cannot be determined with any degree of accuracy.

Group 14

Group 14 is another short sequence from the initial decortication of a grey flint nodule with a relatively thick cortex (Figure 6.128). The sequence is composed of three flakes. The first of these is a large, thick hard hammer flake with a cortical platform. The dorsal surface indicates at least two flakes were removed before it. The second flake was removed from the opposite edge and has signs of possible platform preparation. The final flake shows a missing removal between it and flake #2. Again, the platform is unprepared and the termination is feathered, even though the flake has fractured across the middle at what is apparently a step fracture.

Group 15

The final sequence is also the most complete, with twenty-one flakes refitted to a small handaxe roughout. The raw material used is a grey flint with a relatively thick cortex (Figures 6.129-6.132). Several cortical flakes are missing that must have been removed prior to the first refitted flake. The initial removal in the sequence has a cortical platform and the dorsal surface shows one previous removal. The knapper then turns the blank over and knaps from the same point. A fan shaped flake was removed, which is missing from the sequence [2]. The next flake opens up a platform for further flaking [3]. The platform for this flake was created by the removal of flake #1 and shows evidence for preparation. The knapper then turns the blank back over and starts knapping by rotating anticlockwise of flake #1. The flake removed has a large flat platform with a cortical dorsal surface [4]. The knapper then rotates clockwise, removing a small pointed flake [5] and a larger fan shaped flake [6], both with prepared platforms.

After removing the previous flakes, the knapper rotates the nodule anticlockwise. The next flake, which is removed below flake #5, shows evidence of platform preparation, as well as dorsal scarring that indicates several missing flakes [7]. This is followed by another flake that is missing its butt, which may have been caused by a flaw in the raw material. The knapper then beings to knap the other edge of the nodule, removing a series of flakes that all show evidence of platform preparation, as well as varying degrees of fragmentation [9-14]. During the removal of these flakes, the knapper rotates the nodule in a predominantly clockwise direction.

The knapper then turns the nodule over again. A large flake is missing across this face, which is followed by a second flake, of which only the tip remains [15]. The termination of both flakes appears to have left a crest in the flint. This may have been cause by imperfections in the raw material used. The knapper attempts to correct this with the removal of another flake [16], which shows signs of multiple hammer blows required to remove it. The direction of rotation to this flake is unknown, but the dorsal surface shows that several flakes were removed prior to it, all of which have terminated at hinge fractures. However, the termination of this removal appears feathered, though the butt has fractured. The knapper then moves to a platform created by flake #14, and proceeds to work along the edge of the nodule, rotating it clockwise and removing a the final five flakes in the sequence [17-21]. These flakes show evidence of platform preparation and the dorsal surfaces on most indicate missing flakes, though these would follow the same pattern of clockwise rotation.

Overall, this sequence is mostly complete. The resultant roughout may have been discarded due to the fact that reduction resulted in it becoming too small. There is some definite evidence of skill in the knapping procedure, such as the knapper's ability to prepare the platforms of the flakes and correct mistakes when they occurred. Some areas also attest to a level of difficulty in removing flakes, which resulted in several hammer blows being needed.

ANALYSIS OF THE CADDINGTON ASSEMBLAGE

After analysing the refitting sequences from Caddington, the data was explored using principal component and cluster analysis in the same manner as was conducted for the Boxgrove sample. The data were converted into percentages in order to provide a level of standardisation prior to their analysis. The results of the analysis, along with a comparison with the replica assemblage, are presented below.

Principal Component Analysis

The principal components for the Caddington sample were extracted using the SPSS program FACTOR with no rotation applied. From the eight variable recorded a total of three components were produced with eigenvalues greater than 1 (see Table 6.8). These components account for 75.8% of the total variation within the data recorded:

- The first component is composed of variation in the amount of flawed terminations, clockwise rotation, removals from the same location and those flakes with missing butts.
- The second component displays variation in the amount of fractured flakes and anticlockwise rotation.

- The final component comprises only variation in unknown rotation.

The high levels of variation within the data and displayed in the components could be interpreted in a variety of ways. However, what is clear when returning to the refitting sequences is that there is a large disparity in the number of flakes within each of the groups studied. Only eight of the fifteen groups studied had a total of six or more flakes. Therefore, it is highly likely that the principal component analysis has been distorted by the data recorded for the groups with fewer flakes. For example, a sequence with ten flakes that shows one flawed termination would give a result of 10%, while a sequence with only three flakes increases this to 33.3%. Therefore, the short sequences only provide a snapshot of what happens within reduction, whereas the longer sequences contain more valuable information concerning the knapper's choices throughout the reduction process. This highlights the problems of analysing refitting sequences of different length. As a result, the principal component analysis was run again with those groups consisting of four or fewer flake removed.

The results of this second analysis are displayed in Table 6.9. Again, three components were extracted with eigenvalues greater than 1. The first component is comprised of variation in flawed terminations, platform preparation and clockwise rotation. The second component consists of variation in flake fragmentation and the number of flakes with missing butts, while the final component displays only the variation in removals from the same location.

While there are some similarities with the original principal component analysis, there are also clear differences. Component one retains the high loading provided by variation in flawed terminations and clockwise rotations, but now incorporates variation in platform preparation, which the previous analysis did not show. Component two retains the high loading from the variation in fractured flakes, but variation in anticlockwise rotation has been replaced by variation in flakes with missing butts, which appears to have moved down from component one. The final component has changed from displaying variation in unknown rotation to variation in removals from the same location.

The main variation within the sample comes from component one. Returning to the data for the eight refitting sequences studied (see Table 6.7), it is clear that the majority of sequences display few flawed terminations, though three have evidence for a small degree of hinge and step fractures. The amount of platform preparation shows more variation, though there is a preponderance of flakes that show strong evidence for preparation prior to removal. Only two of the sequences show relatively little platform preparation, and one shows no evidence at all, though this sequence is shorter and may not be representative of the knapper's abilities. It is interesting to note that this latter sequence displays flakes refitted to an associated handaxe or roughout, which may indicate that the knapper was unskilled in platform preparation. Alternatively, they may have been able to produce adequate results without the need for preparation. When looking at the actual sequence itself, though, it is clear that scar patterns on the surface of the flakes and roughout show a high level of hinge and step fracture terminations, despite no flawed terminations being recorded for the extant flakes studied. Therefore, it is possible that the lack of platform preparation may be equated with a lack of skill in this case.

The most interesting aspect, however, is the large variation in clockwise rotation. Variation in other forms of rotation is much lower, but when studying the data, there appears to be a division between those sequences that use a predominantly clockwise rotational schema, and those that use a predominantly anticlockwise schema. As rotation of the nodule is, for the most part, dictated by the knapper's goals and the specific method with which they choose to reduce the nodule, the presence of two rotational schemes could highlight idiosyncrasies that may be linked to the individual knappers at Caddington. However, due to the failure of the methodology to trace the imprint of the knappers in the replica assemblage, further analysis must be done to investigate this further. Unfortunately, at present, this is beyond the scope of this thesis.

While it appears that the first component may highlight variables that could be linked to idiosyncrasies in the knapper sequences, the second component appears to highlight variation in the raw material properties of the flint used. At Caddington the raw material quality is much lower than that seen in both the replica and Boxgrove samples. This explains the high level of flake fragmentation seen. In those sequences where flake fragmentation is lower, this can partially be explained by the stage of manufacture. In both Group 5 and 15, the majority of the flakes show the initial decortication stage of reduction, where large flakes are removed that are thicker and, therefore, less likely to fracture due to the force travelling through the flint. In the case of Group 15, the fact that the flakes are glued together also meant that close inspection of many of the flakes was impossible, which may have biased the count for this variable.

Variation in the amount of missing or shattered butts may also be attributed to the quality of the raw material. However, at Caddington, there are differences between the amounts of fragmentation and flakes with missing butts that may indicate that this variable is also influenced by the knapper's control. For example, Group 12 shows a high number of fragmented flakes, but low amounts of butt shatter, which may indicate that the knapper had some form of control over the force applied during the knapping procedure. However, returning to the actual sequence itself, Group 12 also shows initial decortication. Here the flakes are seen to have larger and thicker platforms, which are more likely to have been able to withstand the percussive blow used to remove them. Therefore, it is highly likely that the stage of the reduction sequence studied has a strong influence over this variable.

The final component may also be explained by the sequence that is being studied rather than the idiosyncrasies of the knapper. In this case, the length of the sequence studies appears to affect the component, which shows variation in the amount of removals from the same location. It is only the two longest sequences of flakes that display any evidence from flakes removed with little to no rotation applied to the nodule used. Therefore, it is likely that shorter sequences do not show evidence for this type of removal, as they are not fully representative of the totality of the reduction sequence that they are a part of.

Comparison to the Replica Assemblage

Comparing the results of principal component analysis from Caddington to that from the replica assemblage it can be clearly seen that they are very different. The variation in the amount of missing butts and flake fragmentation play a lower role in the total variation at Caddington compared to the replica assemblage, while flawed terminations show a much higher degree of variance. In addition, the variation in anticlockwise rotations seen within component one from the replica assemblage is replaced by variation in clockwise rotations in the Caddington sample. It is clear that there are major differences between the two refitting assemblages and this highlights the inability of the replica sample to provide an accurate representation of this archaeological material.

Reasons for the disparity between the two samples are complex. However, one main difference is that the Caddington assemblage is made on relatively low quality flint nodules obtained within the local vicinity of the site, while the replica assemblage was produced upon a variety of flint raw materials that the knappers were able to select according to their preferences. Therefore, it is possible that by allowing the knappers to select their own raw materials in the anticipation that this would provide an organic replica assemblage, the data collected has been affected when compared to the archaeological assemblages, where raw material is generally sourced from amongst what is available locally.

In addition to the problems presented by raw material choices, there is a clear difference in the rotational scheme seen at Caddington. While the replica sample shows a much higher variation in anticlockwise rotation and no clear preference given to a particular direction, the Caddington refitting groups show more variation in clockwise rotation and clear differences between a preference for rotation in one direction over the other. However, it must be noted that the direction of rotation, while predominantly directed by the knapper's choices in the reduction strategy in compliance with the goal they are attempting to achieve, can be affected by conditions introduced by both raw material properties and mistakes brought about by knapping skill. Therefore, this aspect of the methodology must be investigated in more detail prior to any firm conclusions being drawn.

Cluster analysis

Cluster analysis was also performed on the Caddington sample, using the data from the principal component analysis for the eight longer sequences. The analysis was carried out using the HIERARCHICAL CLUSTER program within SPSS. The data from this analysis is displayed in Table 6.10. Again, the clusters could not be used to identify the products of individual knappers, due to the failure of the methodology to extract this from the replica assemblage. However, the analysis was used to highlight which variables had the greatest influence over the clusters that were formed.

Clusters produced through the analysis were plotted as scatter diagrams using the principal component data (see Figures 6.133-135). These diagrams show that all of the variables contribute to the clusters produced, though it is component one and component two that produce the tightest clusters (see Figure 6.133). The results are different to both the replica and Boxgrove samples, with the former showing only tight clusters with components one and two, while the latter displayed tight clusters with components two and three.

The clusters for the Caddington sample, therefore, appear to be dictated by a combination of all the factors investigated, though it is those variables within component one and two that have a greater effect. However, as noted above, these variables may result from a variety of factors outside of the knapper's own idiosyncrasies. As a result, further investigation is needed in order to separate these variables and establish to what extent they are a result of the knappers choices, or constraints due to the properties of the raw material being used.

Summary

The Caddington assemblage differs greatly from both the replica and Boxgrove samples. While the majority of the variation within each of the variables studied can be attributed to the raw material being used, there is a distinct separation of the sample into sequences that show a preference for clockwise rotation and those which show a preference for anticlockwise rotation. While this may be due to differences in the length of the sequences studied, further analysis is needed to establish whether this is true, or whether the rotation of the nodule is the result of knapping idiosyncrasies. However, the presence of possible patterns in the rotation of the raw material during the knapping procedure does pose a potentially profitable avenue for exploring idiosyncrasies in stone tool manufacture and should be researched further.

In addition, the sequences from Caddington also support the evidence from Boxgrove, which indicates that refitting groups are most likely to originate from earlier stages of reductions rather than thinning and finishing stages. As a result, this may have a large effect on the results of the analysis, especially given the evidence from the replica sample that indicates initial decortication and shaping of the nodule is a less structured process designed to prepare the nodule for the more systematic flaking of later reduction stages.

DISCUSSION AND SUMMARY

The application of the proposed methodology to refitting sequences from both replica and archaeological material has served to highlight a number of important points concerning our ability to trace the idiosyncrasies of individual knappers. The first of these points is that the methodology failed to cluster the products of the knappers in the replica assemblage, which has been mainly attributed to the fact that raw material properties have a large impact on the method of reduction chosen. Chief amongst these properties are the initial shape of the nodule chosen, which can significantly alter the initial reduction strategy applied, and the quality of the raw material chosen, which will affect the amount of flake fragmentation and flawed terminations seen beyond what the knapper is able to control through their own skill.

Secondly is the fact that the variation within the replica assemblage does not correlate well with that seen in the archaeological assemblages. These differences serve to highlight the issues in attempting to replicate a sample of refitting material that is comparable to that found within the archaeological record. In addition, the choice to allow the knappers in the replica assemblage to choose their own sources of raw material appears to be a poor reflection of what occurs in the Lower Palaeolithic, where hominins are limited, for the most part, to what is available locally (Féblot-Augustins 1999; White 1998a). The archaeological samples also indicate that the vast majority of thinning and finishing flakes are not refitted to sequences, leaving only initial cortical removals and early thinning flakes to be analysed. Obviously this will have a large impact on the analysis of these sequences, especially given the observation that early stages of reduction do not necessarily reflect the knapper's personal reduction strategy accurately.

The third point is that the archaeological assemblages also do not correlate well. There are clear differences between what is occurring at Boxgrove in comparison to Caddington. As discussed above, a large factor in these differences is likely to be differences in the raw material available to the hominins, with Boxgrove displaying use of high quality flint sourced from the nearby chalk cliff, while at Caddington the available nodule were of a lower quality. However, the difference in rotational schemes at these two sites is interesting and it is suggested that this must be investigated further, though this is beyond the scope of the current inquiry.

CHAPTER SEVEN
THREE-DIMENSIONAL ANALYSIS OF HANDAXE FORM

INTRODUCTION

The previous chapter presented the results of the first of three experiments discussed within this thesis. This aimed to show whether idiosyncrasies in the reduction strategy used could be traced back to the individual through the study of refitting débitage. While the results from this experiment have shown that this is not possible within current methodological frameworks, it highlighted the fact that a variety of factors not only mask the individual knapper's imprint, but also influence the knapping strategy chosen during the production of a tool. In addition, comparison of the replica assemblage to the archaeological material shows little correlation, which serves to underline the difficulties in accurately or meaningfully replicating an archaeological assemblage.

This chapter will present the second of these experiments, namely the analysis of the three-dimensional form of handaxes from the replica assemblage, as well as from the sites of Boxgrove, Caddington and Foxhall Road. The aim of this experiment was to show whether the finished three-dimensional form of a tool contains any record of a knapper's idiosyncrasies, or if, like the refitting analysis, other factors are found to mask the choices made by individuals during handaxe manufacture. Each of the assemblages was analysed using the methodology detailed in Chapter Three. Handaxes were scanned to produce a three-dimensional point-cloud, which was imported into ArcMap (ESRI, Version 9.3) in order to extract aspect and slope data. The aspect data reflects the direction of orientation of each point in a handaxe's point-cloud across the eight cardinal directions (Figure 7.1). This analysis was used to explore the possibility of analysing the overall orientation of each tool's morphology and, by extension, the orientation of flake scars upon the handaxe's surface. The slope data corresponds to the angle of slope for each point and was recorded using five-degree increments between 0° (flat) and 90° (vertical). These data were analysed to examine differences in the angles of flaking and degree of overall thinning applied to each tool (Figure 7.2). In both cases, data were recorded as percentage counts based on the total number of points in each handaxe's point-cloud, as described in Chapter Three. The datasets for each assemblage can be found on the supplementary data disc at the rear of this volume. The data from each assemblage was then explored using principal components analysis in order to reduce the total number of variables and examine the results using scatter diagrams. Such visual representations of the data allow for any clustering of the handaxes to be examined and described in detail. Finally, the results of each of the analyses were compared in order to draw relevant conclusions concerning whether this methodology can be applied to the study of the individual within the Palaeolithic.

THE REPLICA ASSEMBLAGE

The aspect and slope data from all twenty-six handaxes associated to the replica assemblage were analysed using principal component analysis in order to extract components with eigenvalues greater than 1.0. As these extracted components account for the majority of the variance within the sample, it was determined that these would be the most useful for formulating any interpretations of the aspect and slope data. The results of these analyses will now be discussed.

Results

Aspect analysis

The results of the principal component analysis applied to the aspect data recorded for the surfaces of each handaxe are presented in Table 7.1. As the table shows, a total of three components were extracted, accounting for 68.53% of the total variation within the sample:

- The first component can be correlated mainly with the southerly variables.
- Component two, on the other hand, is heavily correlated with the north and northeast variables.
- Finally, component three corresponds to the northern variable.

On reflection, the weightings for these components can be explained quite straightforwardly. Although the direction of flaking will have also contributed to the results from the aspect analysis, it appears that the results reflect the shape of the tools to a greater extent. Pointed handaxes will naturally have a narrower tip, leading to a lower number of points recorded for this area when scanned and, hence, lower counts for the number of points that display northerly orientations. In addition, due to the pointed nature of these tools, the butt area is also likely to have a lower surface area when compared to ovate handaxes, which display a more curved edge in planform (see Figure 7.3). As a result, they will also likely have lower counts for the number of points associated to the southerly variables as well. Therefore, it appears that the results of the analysis reveal more about the shape of the tools being studied, as opposed to any traits that might reflect idiosyncrasies that are linked to the choices made by knappers during tool production.

The results of the principal component analysis applied to the aspect data recorded for the handaxes as whole units is shown in Table 7.2. Again, three main components were extracted from the principal component analysis, which accounted for 73.06% of the total variation. The results are similar to those shown in the previous analysis:

- The first component correlates to the southerly variables
- Component two is correlated to the north and northwest variables.
- Finally, component three is correlated to the northeast variable.

Once again, it appears that the majority of variation within the sample is dominated by differences in shape, resulting in the imprint of the individual knapper being hidden.

The results of the principal component analyses were plotted using scatter diagrams (Figures 7.4 and 7.5). Those that show the relationships between handaxe surfaces demonstrate that 'genetically' associate surfaces[4] generally do not cluster together. This may indicate that the knapper's approach to each face of the tool is subtly different, leading to variation in knapping strategy that produces this dissimilarity. However, the extent to which this hypothesis is true cannot be ascertained from the data at hand.

Given the fact that handaxe surfaces do not group together, cluster analysis was carried out using the data from the whole unit analysis. This attempted to produce meaningful groups within the data. The results of the cluster analysis were compared to the known values of the knappers to see if the technique was able to succeed in separating the data based on the individuals who had produced the assemblage (Figure 7.6). This comparison clearly indicates that the analysis of the aspect data was unable to attribute the tools to their respective knappers correctly.

Slope analysis

The results from the principal component analysis of the slope data, as applied to the handaxe surfaces, are displayed in Table 7.3. From the analysis, four components were extracted. The four components represent 89.42% of the total variation within the sample:

- The first component extracted correlates with the variables between 25° and 85°. High values in this component appear to reflect increased angularity of the surfaces.
- The second component can be correlated with the variables between 70° and 85°, which is suggested to relate to more extreme angular surfaces, or possibly step/hinge fracture scars.
- The third component is correlated with the variables between 15° and 25°, with high values in this component corresponding to handaxes that have been intensively thinned.
- The final component is predominantly correlated with the highest slope variable, namely the five-degree increment between 85° and

[4] The phrase 'genetically associated surfaces' will be used continually throughout this chapter and the rest of this thesis in reference to two opposing surfaces from a single handaxe.

90°. Again, high values in this component reflect extreme angularity on the surface of the tools.

Of these components, the fourth may possibly have been introduced by #26, which produced a high number of points with steep slope values. This is due to a flake removal along the edge of the butt that is perpendicular to the surface of the handaxe (see Figure 7.7). This would also account for the fact that surface 26T appears to be an outlier in the scatter diagrams that were produced (see below).

The results from the principal component analysis of the slope data from the analysis of the handaxes as whole units are presented in Table 7.4. A total of three components were extracted, accounting for 85.72% of the total variation:

- Component one is similar to that produce by the initial analysis on the handaxe surfaces, with the majority of the variation correlated to those variables between 25° and 75°, as well as the 80°-85° variables.
- The second component is also similar, with the higher increments between 75° and 85° being most strongly represented.
- However, the final component is different and appears to be an amalgamation of components three and four from the previous analysis. This component is predominantly correlated to the 20°-25° and 85°-90° variables.

This difference may be a result of collating the data in order to represent the tools as whole units, increasing the variation amongst the higher slope variables, the outcome of which has been the inclusion of this variation in the first and second components. The results themselves, however, suggest that the majority of the variance results from differences between ovates that have been extensively thinned and those that show thicker and more angular profiles.

Again, the principal component data was plotted using scatter diagrams (see Figures 7.8 and 7.9). The graphs of the principal component results from the handaxe surface data display limited distinct clusters of handaxes. In addition, they show that 'genetically' associated surfaces generally do not cluster together. This is similar to what is seen in the results from the aspect data. Again, this is taken to reflect the fact that knappers may have approached each face of a tool in different ways, producing morphological variability between associated surfaces. Furthermore, the inability for 'genetically' associated surfaces to group together may also reflect a lack of symmetry imposed by the knapper on the profile of the tool.

On the other hand, the scatter diagrams produced from the whole unit results display a clear separation of the tools, especially where components one and two are concerned (Figure 7.9a). It appears that this distinct clustering may indicate differences in the shape of the tools, given that handaxes that fall within the bottom left of the scatter, such as #10, #20 and #24 are all ovates, while those in the top right quadrant, for example #16, #17 and #26, are pointed forms. As a result, it is highly likely that the variance within the sample reflects the overall morphology of the tools, as opposed to detecting subtle idiosyncrasies on the part of the knappers involved.

As the surface data continues to show little clustering of associated handaxe surfaces, cluster analysis was performed using solely the whole unit data. The results from this analysis were used to isolate clusters amongst the tools. A comparison was made between the suggested clusters and the known values of the knappers (see Figure 7.10). As was seen in the analysis of the aspect data, the cluster analysis was unable to accurately link the tools to the knappers who had produced them. The slope analysis appears to reflect factors that are not strongly associated with an idiosyncratic imprint that is the result of a knapper's actions made throughout the knapping procedure.

When the identities of the knappers involved in the replica assemblage were revealed, the analysis of the slope data presented one interesting result. Although the handaxes made by the majority of the knappers show no obvious clustering, five of the tools produced by Knapper 1 do cluster together quite tightly. Although this is a single lone occurrence, it does suggest that an individual knapper may strive towards producing tools with a profile of a similar thickness and refinement. It should also be noted that the outliers from Knapper 1's group, such as #23 and #26, are more classically pointed forms, while those tools that do cluster are ovates. This also serves to emphasise that shape is likely to be a primary influence over the results.

Summary

The results of the three-dimensional analysis of the replica handaxes indicate that the methodology applied was unsuccessful in its attempt to trace idiosyncrasies in tool morphology that can be linked to the knappers involved in the production of this assemblage. Instead, it appears that the data produced from both the aspect and slope analysis of the replica handaxes is highly indicative of shape. This suggests that the topography of a tool is constrained by the overall shape that is applied to it, rather than reflecting choices made by the knappers themselves. It is also likely that morphological factors, such as the overall slope and angularity of the handaxe surfaces, is governed by the need to produce a desired cutting edge. Ovate tools appear to be thinned extensively, caused by working circumferentially around the nodule to produce a continuous edge and leading to lower slope angles being recorded. Pointed forms, on the other hand, are not as extensively thinned, due to reduction mainly along two working edges, so as not to remove too much of the tools surface area and avoid miniaturisation. Therefore, their surfaces are generally more angular, resulting in higher slope angles.

To test the hypothesis that the results reflect overall shape, Roe's (1964, 1968) typology was used to differentiate the handaxes into pointed and ovate types. This was then mapped onto the results from the analysis of the aspect and slope data (Figures 7.11 and 7.12). As these scatter diagrams show, there is a clear separation between ovate and pointed forms, especially where the first component is concerned. This confirms that the majority of the variation within the replica assemblage relates more to the shape of the tools studied, as opposed to the knappers involved in their production. However, as discussed above, the cluster of ovates made by Knapper 1 demonstrates that knappers may have had an ideal goal in mind when carrying out the final thinning and shaping stages of manufacture, which results in the production of very similar tools. Nevertheless, it appears that individuals within the replica assemblage who choose to conform to an ideal standard are generally concealed by broad scale variation in the habits of other knappers.

Although the analysis of the handaxes according to Roe's typology clearly shows a distinction between pointed and ovate forms in both the aspect and slope analysis, further analysis of the data demonstrates that this differentiation has little to do with general outline shape of the tools. Comparison of artefacts that are closely clustered together in both Figure 7.11 and 7.12 indicates a variety of shape types as opposed to handaxes that are almost identical. Therefore, the variation seen in both the aspect and slope analysis cannot solely be explained by differences in shape.

One possible explanation for the separation of the data according to shape is the mode of manufacture for both pointed and ovate forms. In terms of the aspect analysis, it is possible that the intensity to which the raw material is worked contributes to the results shown. For example, it is common for the pointed forms in the assemblage to be worked around the tip, while the butt receives little attention, resulting in cortex remaining on the tools surface. This results in less varied flake scar orientations due to reduction being localised to a particular part of the tool. On the other hand, ovate forms are much more intensively worked all around the tools edge, producing a more varied combination of flake scar orientations. In addition, the focus on reducing the tip and sides of pointed forms results in a reduction in the surface area of the tip. As a result, less data points can be recorded during the three-dimensional scanning of this part of the tool when compared to ovates. Therefore, there may also be a methodological issue in the use of the aspect analysis that explains why shape appears to be a primary factor in the variance seen.

In a similar manner, the same separation seen in the slope analysis can be explained by the extent of thinning applied to the tool. The ovate tools within the assemblage are more intensively thinned when compared to the pointed forms. This would account for the separation of the data according to shape, and also explains why #19, an intensively thinned pointed form, clusters with the ovates. The same can be said of #14, a thicker ovate form with high incidences of step fractures, which clusters within the pointed tools. However, #14 also serves to suggest another factor that may influence the results, namely the influence of raw material. It can be shown that #14 was made on relatively poor quality flint, as discussed in the refitting analysis performed on this tool's débitage in Chapter Six. If raw material factors prevented the thinning of this tool further and also caused the introduction of hinge and step fracture terminations on its surface, then this may also account for why it clusters more with the pointed forms as opposed to the ovate group.

Overall, the analysis of the three-dimensional morphology of the tools in the replica assemblage was unable to accurately trace any form of individual imprint that could be used to trace individual knappers. However, the revelation that both analyses separated the tools according to shape suggests that there are other factors outside of the knapper's influence on tool morphology that account for variation within the assemblage. These factors are explored further through the analysis of material from the archaeological assemblages that were also selected for analysis.

THE ARCHAEOLOGICAL ASSEMBLAGES

While the failure of the methodology to trace the individual knappers means that no accurate comparison can be made with the archaeological record on these grounds, testing the material from the archaeological sites will provide a means to measure differences between the replica and Palaeolithic tools. In addition, it will allow us to test whether the analysis of the archaeological material displays a segregation of tools based upon shape or other factors and how this compares to the results from the replica assemblage. Such comparisons can be used to show whether the replica assemblage provides a sound replication of the archaeological record that we desire to study, and will highlight any discrepancies between replicated technology and that which is found within Lower Palaeolithic contexts.

Therefore, the handaxes from Boxgrove, Foxhall Road and Caddington were analysed using the same methodology applied to the replica sample. The three-dimensional scans produced from these tools were subjected to both aspect and slope analysis as described in Chapter Three. In addition, principal component analysis was applied to the data recorded for each site and those components with eigenvalues greater than 1.0 were extracted in order to explore the data further. Due to its failure to differentiate the replica assemblage on the basis of its knappers, hierarchical cluster analysis was not applied to the archaeological material. Finally, graphical representations of the results were produced using scatter diagrams, as per the replica assemblage, with variables including shape, site and context used to formulate interpretations and enable a rigorous discussion of the results.

BOXGROVE

Handaxes from the two stratigraphic units described in Chapter Four were selected to form the Boxgrove sample. These assemblages were analysed separately, as well as grouped together to test whether any differences could be shown to exist between the two excavated units. All of the handaxes were scanned and the point-cloud data analysed as discussed in Chapter Three. Principal component analysis was then applied to the resultant datasets. The results of these analyses will now be discussed.

Analysis of Boxgrove Unit 4/3

Aspect analysis

The results of the principal component analysis of the aspect data from the handaxe surfaces from Unit 4/3 are shown in Table 7.5. The extracted components account for 79.37% of the total variance within the sample:

- The first component is correlated with the southerly variables.
- Component two is related to the southeast variable.
- Component three equates to the variable for southern aspect.
- Finally component four is associated to the southwest variable.

This is interesting, as it suggests that there is little variation in the northerly variables, which would usually occur around the tip of the handaxe, while the main source of variation appears to be centred on the butt area of the handaxes.

The results from the analysis of the whole unit data are shown in Table 7.6. The three components extracted explain 68.52% of the total variance within the sample:

- The first component extracted can be mainly correlated to the southeastern variable.
- The second component, however, provides the greatest dissimilarity to the analysis of the surface data. This component can be mainly correlated with the western and northwestern variables.
- The third component accounts for variation in the values for the southern variable.

Again, the majority of the variation within the sample appears to be explained by differences in the southerly variables, which can be equated to differences in the butt area of the handaxes studied. The variation in the west and northwest variables that appear to load component two require further investigation, though it is possible that these may indicate the presence or absence of tranchet flake removals.

The scatter diagrams from the results of the handaxe surface analysis are similar to those from the replica assemblage, in that there is little clustering of 'genetically' associated surfaces (Figure 7.13). This continues to suggest that there is a certain amount of variation between the two faces of a handaxe, which may indicate differences in the method of thinning and finishing applied to each surface.

The graphs of the whole unit data, however, are more interesting (see Figure 7.14). When Roe's typology is used to differentiate the tools, it is clear that there is no patterning that can be explained by the outline shape of the handaxes. This strongly contrasts with the results from the replica assemblage, where the handaxes were clearly grouped according to whether they were classed as ovate or pointed. The plots also show evidence of distinct outliers and discrete clusters of handaxes. Within Figure 7.14a outliers with high values in component one display extensive working around the butt, while those that have low values in this component are cruder and show limited flaking of the butt. There is also a cluster of seven handaxes near the top of this diagram that display similar intensive working applied to the edge of the tool that provides a high signature in component two, which accounts for the northwest variable. However, of these tools, two are less intensively worked (#193 and #197), though very similar in appearance. Figure 7.14b continues to emphasise these outliers while introducing further clusters. Of these, one displays four handaxes (#164, #170, #173, and #174) that all display high intensity working along the west edge, while another indicates tools with comparatively wide butts with south facing flake scars (#154, #184, #185 and #202). Finally, Figure 7.14c shows a greater spread throughout the tools analysed, with those on the right of the scatter displaying high intensity working along the left, or west facing edge, while those on the left show more intensive flaking along the north and east edges.

While there is some evidence that clusters contain tools that are comparatively similar in terms of their overall appearance and flake scar patterning, for example handaxe #198 and 201, it is important to note that the presence of tools that are very dissimilar within these clusters tends to emphasise that clustering within the graphs cannot be linked entirely to knapping idiosyncrasies. This is compounded by the inability of the methodology to differentiate the tools in the replica assemblage based on the knappers who created them. The interpretation of similarities between tools must, therefore, be approached with caution.

Slope analysis

Table 7.7 shows the results from the principal component analysis of the slope data from the handaxe surfaces. The extracted components account for a total of 84.96% of the variance in the sample:

- The first component is correlated to the variables between 35° and 85°. This is related to increasing angularity of the handaxes.
- The second component correlates to the variables between 0° and 10°, as well as 75° and 90°. High values in this component appear to represent extremes of thinning and angularity, while lower scores account for moderate thinning.
- The final component is mainly correlated to the 20°-25° variable, high values of which represent extensive thinning and limited angularity.

The results from the analysis of the whole unit slope data are displayed in Table 7.8. The components extracted during the analysis account for 88.41% of the total variance:

- The first component is comparable to that from the analysis of the handaxe surfaces and is correlated to the variables between 35° and 85°.
- The second component is also comparable, showing heavy correlation with the variables between 0° and 10°, as well as 75° and 90°.
- The final component differs slightly and is can now be correlated with the variables between 20° and 30° and the 85°-90° increment.

The scatter diagrams from the results of the handaxe surface analysis are shown in Figure 7.15. In the same manner as the aspect analysis the majority of the handaxes studied show a clear variation in the slope of the two faces. While there is some localised clustering of surfaces from the same tool, for example #161 and #172, the results tend to agree with the replica assemblage and suggest that there is an element of variation between different sides of the same handaxe. Whether this is due to choice or is the result of other factors remains to be discussed.

Figure 7.16 displays the scatter diagrams for the results of the whole unit analysis. Using Roe's shape typology, it is clear that there is some differentiation according to whether the tool is of pointed or ovate form. However, the distinction between the two is not clear. Also, the diagrams show that the ovates tend to cluster towards the right, which is the opposite to that shown in the results of the replica assemblage. All of the plots show a distinct central cluster, along with several outliers. These outliers generally show higher slope values caused by the occurrence of hinge and step fractures, as well as displaying much thicker profiles. In Figures 7.16b and c, #182 and #167 also occur as outliers. This appears to be due to the presence of large flatter areas on the surfaces of these tools that produce lower slope angles. It is possible that these handaxes were produced on flake blanks, though further investigation of these tools is needed to confirm this hypothesis. Overall, the results appear to differentiate the handaxes based on subtle differences in the way that they have been thinned, as well as possibly indicating distinctions in knapping skill evidence by those outliers that display greater incidences of step and hinge fractures.

Analysis of Boxgrove Unit 4u

Aspect analysis

The results of the principal component analysis of the aspect data from the Unit 4u handaxe surfaces are shown in Table 7.9. The components extracted from the analysis account for 78.19% of the total variance of the sample:

- The first of these components can be correlated to variation in the north and south variables.
- The second component corresponds to the southeast and northwest variable, while the third component is correlated with only the southwest variable.

- The final component is also correlated with the northwest variable.

The results of the analysis differ when compared to those from Unit 4/3, though the predominance of northerly and southerly variables throughout continues to support the hypothesis that the analysis is detecting variation in the surface area of the tip and butt and, hence, possible differences in the overall morphology of the tools.

Table 7.10 displays the results of the principal component analysis of the whole unit data. The extracted components account for 70.55% of the variance within the sample:

- The first component corresponds strongly to the northwest and southeast variables.
- The second component is similar to the first component from the previous analysis, with variation in the north and south variables providing the majority of the variance.
- The final component can be correlated mainly with variation in the southwest variable.

Again, the variance within the sample appears to be dominated by variation in the northerly and southerly variables. However, similar to the analysis of Unit 4/3, the appearance of westerly variables within the components of both of the analyses performed on Unit 4u requires investigation.

Following the principal component analysis, the results were plotted as scatter diagrams (Figure 7.17). Again, the results from the analysis of the handaxe surfaces do not produce clusters of 'genetically' associated surfaces. This continues to emphasise that there are clear differences between surfaces related to the same tool. On the other hand, the graphs of the whole unit data are similar to those from the analysis of Unit 4/3 (Figure 7.18). The application of Roe's typology continues to show that the handaxes from Boxgrove do not group according to their outline shape. The graphs tend to show a main central cluster with several outliers surrounding it. These outliers tend to be cruder forms that are less intensively worked; yet handaxes that cluster together tend not to show visible shared idiosyncratic traits. For example, #94, #123 and #129 all show similar aspect traits, but #123 is more elegant compared to the others. While most outliers appear to be crude or less intensively worked, handaxe #108, which is an outlier in Figures 7.18b and c, is an almost perfect ovate form. It shows a high value for component 3, which is correlated to the south west variable. This value may have been produced by a large flake removal across the butt that would have produced high values for the southwest variable (see Figure 7.19).

Therefore, the graphs of the aspect data from unit 4u tend to indicate that there is some degree of standardisation amongst the handaxes studied. The tools that form outliers on the graph are generally those that are cruder and less intensively worked around the edges. However, there are some anomalies within this pattern and it should also be noted that the clusters seen do not indicate handaxes with visible (eye-balled) shared idiosyncratic traits.

Slope analysis

Table 7.11 displays the results of the principal component analysis of the slope data from the Unit 4u handaxe surfaces. The four extracted components account for 90.11% of the total variance within the sample:

- The first component is correlated with all the variables between 35°-85°, and is comparable to the first component from the analysis of the slope data from Unit 4/3. Again, it is suggested that this represents differences in the angularity of the handaxe surfaces.
- The second component is also comparable to the results from Unit 4/3, displaying strong correspondence to the variables between 0°-15° and 70°-90°.
- The final two components do not show weighting for any variable above 0.5. However, the third component does display weighting above 0.4 for variables between 20°-30° and 75°–80°, while the

fourth component shows weighting above 0.3 for those variables between 55º-65º.

Table 7.12 displays the results of the principal component analysis of the whole unit data. The three extracted components account for 87.66% of the variance within this sample:

- The first component is relatively similar to that from the analysis of the surface data and can be correlated to variation in the variables between 35º-90º.
- The second component corresponds to the variation in the variables between 0º-15º and 70º-90º. This may be partly associated to the presence of step fractures, but the weighting for low slope values complicates this interpretation.
- The final component shows no variables that are weighted over 0.5. However, this component can be correlated to the variables between 20º-30º, which are weighted over 0.4. High values in this component appear to correspond to extensive thinning.

The scatter diagrams of the results from the analysis of both handaxe surface and whole unit data are displayed in Figures 7.20 and 7.21 respectively. In the same way as the previous analyses of the handaxe surfaces, there is little clustering of 'genetically' associated surfaces. While there are some instances where surfaces related to the same tool do cluster, such as is the case with handaxe #86 and #136, the majority of the handaxe surfaces show no consistency in how they cluster. Again, the results agree with those from the replica assemblage, suggesting that the two surfaces from a single handaxe often show little correlation. This may indicate differences in the way that each side of a handaxe has been thinned.

The results of Roe's typology were used to differentiate the data from the analysis of the handaxes as whole units. As shown in Figure 7.21, the results do not appear to cluster according to the outline shape of the handaxes studied. However, there does appear to be a differentiation between a tight central cluster and several surrounding outliers. A closer analysis of the results shows that these outliers are those handaxes that are thicker and feature more step and hinge fractures, such as handaxe #88 and #125. Therefore, it appears that the graph shows a differentiation between those handaxes that have a standardised level of refinement and a series of tools that do not meet this standard due to either flaws in their manufacture or a lack of extensive thinning.

Analysis of the combined Boxgrove assemblage

Following the analysis of the Unit 4/3 and 4u assemblages, the data from these units were combined in order to detect the possibility of any distinction between the handaxes recovered from these strata. Both aspect and slope data were used to produce comparisons, although the analysis focuses explicitly upon the whole unit data for the handaxes, given that the previous analyses display limited clustering of 'genetically' associated surfaces.

Aspect analysis

The results from the principal component analysis of the aspect data for the combined Boxgrove assemblages are presented in Table 7.13. A total of three components were extracted, which explain 67.91% of the total variance:

- The first of these components is strongly correlated to the southeast variable.
- The second component is associated with the north and south variables.
- The final component mainly corresponds to the south west variable.

The results show that the variance is strongly connected to variation in the southerly variables, while component two indicates some input from the north variable. Again, this is suggested to correspond to differences between the butt and tip of the handaxes being studied and, thus, appears to reflect gross differences in handaxe morphology. Given that these differences are likely to be a product of the three-dimensional scanning technique used, it is probable that the detection of morphological differences may result from a methodological issue.

Scatter diagrams were plotted using the results of the principal component analysis and Roe's typology, as well as the contexts that the handaxes were recovered from, to differentiate the tools (Figure 7.22). As the graphs show, there is no significant differentiation of the handaxes based on either their shape or contextual data. However, it is interesting to note that Unit 4u does show a greater spread within the scatter diagrams when compared to Unit 4/3. Overall, though, it appears that there is little difference between the two assemblages studied. In terms of the handaxes under analysis, the scatter diagrams appear to indicate a notable level of standardisation, with no distinct clusters of tools present. Outlying handaxes are, once again, those that are cruder implements that do not conform to the standard seen amongst the other tools.

Slope analysis

The results from the principal component analysis of the slope data are displayed in Table 7.14. The analysis extracted three components, which account for 87.43% of the total variance within the sample:

- The first of the extracted components is strongly correlated to the variables between 35°-90°. Higher values for this component are linked to increased angularity of handaxes morphology.
- The second component corresponds to the 0°-15° and 75°-90° variables.
- The final extracted component shows no variables loaded above 0.5. However, the 20°-25° variable is loaded above 0.4. Therefore, high values for this component appear to be linked to increasingly thinned handaxes.

These results are comparable to those from the replica and other archaeological assemblages studied.

Scatter diagrams of the results from the principal component analysis were plotted using Roe's typology and the context data to differentiate the handaxes based on shape and stratigraphic unit (Figure 7.23). Again, the graphs show no differentiation of the handaxes according to their shape or the unit from which they were excavated. Unit 4u continues to show a higher level of variation compared to Unit 4/3, though both of the assemblages tend to cluster within the centre of the plot. It is possible that this may be due to a greater time depth of the deposition of the artefacts within unit 4u. As two separate, though converging clusters are present within Unit 4u, with three relatively dense patches of material, compared to a single high density of handaxes in Unit 3/4 (Pope 2002: 196-7), this may be true, though an accurate determination of the time depth is not currently available. Handaxes that fall outside of this central cluster tend to display thicker profiles and higher incidences of step fractures. Therefore, these do not conform to the general level of thinning that is seen amongst the other handaxes within the two assemblages. Overall, it is clear that factors other than handaxe shape and assemblage explain the variance seen within the sample. Given the homogeneity of the raw material available at Boxgrove, it is possible that the outliers that appear may represent examples of poorer knapping skill. However, this would require further in depth analysis.

Summary

The results from the analysis of the Boxgrove material suggest that a high level of standardisation was present and that this continued throughout the stratigraphic units studied. The graphs of the data show, in the majority of cases, that there is a central cluster into which most of the handaxes fall. Outliers to this central cluster are usually those that display a lower intensity of knapping, are cruder in form, or are comparatively thicker in profile.

Evidence from the aspect analysis indicates that high values in the variables studied may result from a higher intensity of flaking or from large flake removals. This introduces a significant problem, as handaxes that cluster together due to high values in particular components may do so for very different reasons. However, closer examination of the data does suggest that in some cases these clusters may indicate potential idiosyncratic knapping patterns, which should be analysed in greater detail.

The results of the slope analysis are highly comparable between the two units studied and suggest that the hominins at Boxgrove thinned their handaxes extensively. While this does not aid the exploration of idiosyncrasies that could be used to trace individuals, it could be used to argue for a general degree of standardisation *at the group level*. Outliers to the central clusters in the graphs are those that do not match this pattern, either due to the fact that the tool was not thinned as extensively, or because of flaws in the manufacturing process.

The evidence for standardisation in tool manufacture at the site continues to be supported when the two units are analysed together. There is no visible separation between the handaxes from the two stratigraphic units, though Unit 4u does suggest a greater degree of variability is present when compared to Unit 4/3. This may, however, be the result of a sampling bias, given that Unit 4u contains 70 tools compared to only 50 studied from Unit 4/3.

The fact that there is no distinction between the handaxes from both units based on their outline shape is interesting, as this is in direct conflict with the results from the replica assemblage. However, this may be explained through further analysis of the handaxes themselves. While Roe's method identifies several of the tools from each unit as pointed in form, many of these are of cordate form and the majority do not display scores below 0.3 for L/L1. Therefore, very few of the tools studied resemble classic pointed forms. As a result, the handaxes show limited gross differences in their outline shapes and generally fall within what has been traditionally classed as ovate and cordate forms.

Overall, the results of the analysis point to standardisation at the group level with little evidence for knapping idiosyncrasies that can be related to individual knappers in any socially meaningful way. However, there are some discrete clusters of handaxes that suggest that non-standardised patterns of flaking exist within the assemblage. Whether these can be linked to an individual knapper or not cannot be assessed at present, but this may point to the fact that evidence of knapping idiosyncrasies does exist, albeit within very fine scales of variation.

CADDINGTON

The handaxes from the site of Caddington were recovered from a total of five brickearth pits (Smith 1894). Due to the fact that the sample size from the majority of these pits can be considered too small to produce significant results, the samples were first analysed as a whole. Following this, the handaxes from the Pit C site, being the largest group of tools from the Caddington complex, were analysed as a separate assemblage. All the handaxes were scanned and analysed as described in Chapter Three. The results of these analyses will now be discussed.

Analysis of combined Caddington assemblage

Aspect analysis

The results of the principal component analysis of the aspect analysis of the handaxe surface data are shown in Table 7.15. A total of four components were extracted. These components accounted for 71.66% of the total variance within the sample:

- The first component is correlated to the north and northeast variable.
- The second component accounts for the south and southeast variables.
- The third component corresponds to the southwest variable.
- Finally, the fourth component to the southwest and northwest variables.

Given that the components are heavily weighted for the northern and southern aspects, the results continue to support the idea that it is variation in the tip and butt of the handaxes that accounts for the majority of the variance within the Caddington sample. However, as the first component is strongly weighted for variation in the northerly variables, it is likely that variation in the tip is a larger factor within the Caddington assemblage. This could possibly be a due to a combination of differences in pointed versus ovate tip shape, as well as tranchet versus non-tranchet sharpening techniques. However, this hypothesis requires further analysis.

Four components were also extracted from the analysis of the handaxes as whole units (see Table 7.16). These components accounted for 76.74% of the total variance within this sample:

- The first component corresponds to the east, west and southeast variables.
- The second component is strongly related to the south and northwest variables.
- The third and fourth components are correlated to the southwest and southeast variables, though it should be noted that the fourth component does not show any variables that are weighted above 0.5.

The results from this analysis are comparable to both the results from the replica assemblage and from the other archaeological assemblages studied. However, as with the analysis of the handaxe surface data from Caddington, the majority of the variance appears to be explained by variation in the tip, as represented by the variables associated to the edges of the tools. Again, this most likely results from variation in morphology of the tools.

The results of both analyses were plotted as scatter diagrams. Figure 7.24 indicates that 'genetically' associated surfaces show little clustering, which is comparable to the results from both the replica and other archaeological assemblages. Scatter diagrams for the results from the analysis of the handaxes as whole units were produced using the results from Roe's methodology for defining shape, as well as the location from which the handaxes were recovered, to look for possible clusters within the data. As Figure 7.25 shows, there appears to be little differentiation between pointed and ovate forms, which is comparable to the results from the analysis of the

Boxgrove assemblages and contrasts against what the replica assemblage displays. In addition, mapping the find locations onto the results also shows that there is little clustering of the results according to which brickearth pit handaxes were recovered from (Figure 7.26), though several discrete clusters do appear. Of these, one cluster that includes #1431, #1514, #1602, #1615, #1643 and #1719 indicates a group of handaxes that show heavy reduction along the right edge, causing high values in the northeast variable. However, this reduction is not consistent, in the pattern in the flake scars is not identical and does not suggest a common reduction strategy, and visually the handaxes do not appear to share any other idiosyncratic traits. In addition, these tools come from a variety of different contexts. This emphasises the fact that the clustering seen is probably not indicative of individual knappers.

Slope analysis

Table 7.17 displays the results of the principal component analysis of the slope data for the handaxe surfaces from Caddington. The analysis extracted four components, accounting for 88.58% of the total variance within the sample:

- Component one can be correlated to the variables between 40º-80º. Again, high values in this component appear to relate to increasing angularity of the handaxe surface.
- Component two strongly corresponds to the variables between 75º-85º. As these are the higher slope variables, this is linked to extreme angular surfaces and possibly incidences of step or hinge fracturing.
- The third and fourth components show no variables that are loaded above 0.4. However, the variables between 0º-15º and 45º-60º are loaded above 0.3 for component three, while the variables between 25º-30º and 65º-75º are loaded above 0.3 for component four.

The results are comparable to those from the replica and other archaeological assemblages, especially in the first two components. However, it must be noted that the results from Caddington show correlations in the first component that begin at the 40-45° variable. This suggests that the handaxes from Caddington show lower variability in the lower slope variables, which may indicate that the variance within the sample originates from a differentiation between those tools that are more refined compared to those that less intensively worked.

Table 7.18 displays the results of the principal component analysis of the whole unit data. Again, four components were extracted, explaining 89.90% of the total variance:

- Component one is again correlated to the variables between 40°-85°. This is similar to that extracted from the analysis of the surface data.
- The second component differs from the previous analysis and corresponds to the variables between 25°-50°.
- The third component is explained by variation within variable 0°-5°. This correlates to extreme thinning of the tools.
- The final component shows no variables loaded above 0.4. However, the variables between 20°-30° and 60°-75° display the strongest loadings.

It appears that the whole unit data also shows strong loadings for the higher slope variables in the first component, while the second component is explained by variation in the middle range of slope variables. Much less of the variance in the sample is explained by variation in the lower slope values, suggesting that these are not a significant contributing factor to the variation within the Caddington handaxes.

Scatter diagrams of the results from both analyses were plotted in the same manner as for the previous analyses. As Figure 7.27 indicates, there continues to be limited clustering of 'genetically' associated surfaces and no significant or meaningful clusters are immediately present. The graphs from the analysis of the whole unit data are differentiated using both the results of Roe's methodology and the locations from which the handaxes were recovered Figure 7.28 shows that there is some differentiation between the handaxes based on shape. However, this only appears to extend to the first two components, which appear to correlate with variation in the higher slope variables. These indicate that a large portion of the variance is produced by differences between thinner handaxes and thicker, more angular tools. This is evidenced by much thicker handaxes on the right side of the scatter in Figure 7.28a, such as #1740 and #1602. On the other hand, much more intensively thinned tools lie on the left, for example #1659 and #1726, which are also very similar in terms of their overall shape and mode of reduction. However, the graphs that exclude component one display limited separation in terms of overall handaxe shape. Instead, these show the formation of a denser central cluster of handaxes, which are surrounded by tools that do not conform to the rest of the assemblage. These outliers generally have either much thicker profiles, or are extensively thinned beyond what is seen in the other tools. Finally, Figure 7.29 displays little clustering of the handaxes according to the brickearth pits from which they were recovered. Although handaxes from the same brickearth pit do tend to cluster together to some extent, the amount of separation between the points is insufficient to suggest that the results indicate separation of the handaxes based on their find location alone.

The graphs show that there are two main outliers. These are #1431, which is made on a flake or 'pot-lid' and is very flat on one side, and #1583, which is similar but more intensively worked. In addition, there are a number of discrete clusters present throughout the graphs. In Figures 7.28a and 7.29a one cluster stands apart from the larger central cluster. This includes #1659, #1718 and #1726, all of which are elegantly thinned ovates. Handaxe #1659 and #1726 are also very similar tools and were recovered from the same brickearth pit and it is suggested, on a visual basis, that the same hand could have created these. In Figures 7.28b and 7.29b, these two handaxes continue to cluster. However, it is impossible to confirm of deny whether these are the product of the same knapper given the inability of the methodology to accurately distinguish the tools related to specific individuals. A second cluster can also be seen within the above scatter that includes a series of cruder handaxe forms, such as #1697, #1706 and #1724. These display very angular surfaces, which appears to be caused by the raw material that was used. In the case of the majority of the handaxes in this cluster the raw material selected was a thick flint nodule or smaller round pebble that appears to have restricted the amount of reduction that could be carried out. Handaxe #1731, on the other hand, has been extensively thinned, but was made from a elongated sub-cylindrical nodule that displays angular natural formations along its cortical butt, which appear to account for the high level of angularity that has been recorded for this tool. The occurrence of single outliers and clusters of handaxes that stand apart form the central cluster continues throughout the graphs and these outliers tend to be those that are grossly different in the way that they have been thinned, the presence of step and hinge fractures and the overall crudeness or refinement of the tool. While some of these may relate to differences in the levels of knapping skill present, it appears that differences in raw material have also played a larger part in the make up of this assemblage.

Analysis of the Caddington Pit C assemblage

Following the analysis of the Caddington assemblage, the handaxes collected from Pit C were analysed separately. However, due to the fact that the analysis of the individual handaxe surfaces failed to produce any meaningful clusters, only the whole unit data for both aspect and slope was used in this study.

Aspect analysis

Table 7.19 displays the results of the principal component analysis of the whole unit data. A total of four components were extracted from the analysis, which account for 82.19% of the variance within the sample:

- The first component is correlated to the north and northeast variables.
- The second corresponds to the southeast, south and northwest variables.
- The third and fourth components are explained by the southwest and southeast variables respectively.

Again, the results of the analysis indicate that the variance within the sample can be mainly explained by the northerly and southerly variables. This emphasises that differences in the tip and butt of the handaxes are a major source of variation, which is likely due to the effect that tool shape has on the distribution of data points within the three-dimensional scans (see Figure 7.3).

Scatter diagrams using Roe's typology to differentiate between points and ovates show that there is little separation of the handaxes based on their shape (see Figure 7.30). Scatter diagrams were also produced using the available context information for the handaxes. Specifically, this referred to whether the handaxe was recovered from Smith's (1894) Palaeolithic Floor or Contorted Drift (Figure 7.31). These diagrams appear to show a distinct division that relates to the contexts from which the handaxes were discovered. This is especially true in the diagram comparing components one and two and continues to an extent in diagrams where component one is a factor. Again, the components appear to reflect variation in the tip and butt of the handaxes under examination. However, differentiation based on context disappears from the graphs that do not include the first component. What the diagrams do emphasises, though, is that the majority of the variance within the aspect data can be correlated to the contexts from which the handaxes originated.

Closer examination of the graphs shows two distinct outliers, #1416 and #1647. These both show high signatures for the northwest variable, which has been caused by extensive flaking on one side of #1647 and large flake removals in the case of #1416. These handaxes do not show any comparable idiosyncrasies that might link them together and the type of flaking technique seen is not comparable. In addition, the tools originate from different contexts. However, it must be noted that the classification of #1647 to the Contorted Drift is based on data from the British Museum collection, whereas Smith's (n.d.) List of Palaeolithic Implements records this tool as recovered after it was "thrown out of the pit". Therefore, it is highly likely that its attribution to the Contorted Drift is erroneous. Other clusters of tools that are closely related include handaxes #1439 and #1562, which also display no visible shared idiosyncrasies. However, #1417 and #1419 are found together and appear very similar to one another. The fact that these handaxes cluster together is interesting, as they were suggested to have possibly been made by the same individual by Bradley and Sampson (1978: 94) In the same way, #1706 and #1732 appear to cluster and show some similarities in their manufacture, though one is classed as pointed and the other ovate.

Although several handaxes do appear to cluster with tools that are similar, many of the clusters present seem to indicate tools with similar idiosyncratic traits. However, the fact that the majority of the variance indicates a distinction between tools from the Palaeolithic Floor and Contorted Drift is an interesting revelation, which suggests that there is a fundamental difference in the three-dimensional morphology of the handaxes from these stratigraphic units.

Slope analysis

Table 7.20 displays the results of the principal component analysis of the slope data from the handaxes treated as whole units. Again, four components were extracted. These components explain 89.56% of the variance within the sample:

- Component one corresponds to the variables between 60º-90º. Like the previous analyses, it is suggested that this is linked to increasing angularity of the handaxe surfaces.
- The second component correlates to the variables between 30º-60º. This appears to correspond to differences between handaxes that have been moderately thinned and those that show more extreme thinning.
- The third component does not show any variables that are loaded above 0.4. However, it can be explained by the variables between 5º-15º and 50º-65º.
- Likewise the fourth component correlates to the variables between 20º-25º.

The majority of the variance in the sample appears to be explained by variation in the higher slope variables, which are linked to more angular handaxes surfaces. This suggests that the variation in the sample may be linked to the refinement of the handaxes, especially in the degree to which individual handaxes were thinned.

The scatter diagrams of the results of the principal component analysis were produced in the same manner as the aspect analysis. The diagrams that include the results of Roe's typology continue to show little differentiation of the handaxes based on their shape (Figure 7.32). However, when the context data is applied (Figure 7.33), there is a significant degree of separation between the handaxes from the Palaeolithic Floor and those from the Contorted Drift in those graphs that include the first component. Although there is some degree of overlap between the two contexts, it is interesting to note that the handaxes from the Palaeolithic Floor present much tighter clusters, indicating a lower level of variation. The scatter diagrams that do not include component one begin to show an increase level of integration between the two groups. However, the handaxes from the Palaeolithic Floor tend to remain in a distinct cluster, while those from the Contorted Drift show a much higher degree of variability.

Within Figures 7.32a and 7.33a there is one distinct outlier. This is #1431, which was also an outlier in the slope analysis for the combined assemblage. The reason for this continues to be the low intensity of flaking and the large flat surface on one side. It is suggested that this is caused by the blank from which it was manufactured, which was probably a flake or a natural 'pot-lid'. While the Palaeolithic Floor assemblage is generally tightly clustered to the left of the graphs featuring component one, two handaxes appear to be situated amongst the Contorted Drift assemblage. These are #1428, which displays a number of step fractures that increased the values for the higher slope variables, and #1515, a highly cortical biface showing limited flaking across its surfaces. In addition, four handaxes from the Contorted Drift are found to cluster with the Palaeolithic Floor assemblage (see Figures 7.32a and 7.33a). All of these tools show a greater degree of thinning either across the entire tool, or across a single surface.

The overall suggestion from this analysis is that the tools from the Palaeolithic Floor present a collection of handaxes that are thinned to a greater extent when compared to those form the Contorted Drift. It is also interesting to note when comparing the graphs that the Palaeolithic Floor assemblage shows a higher predominance of ovate forms compared to the Contorted Drift. This emphasises that there is likely to be two very distinct assemblages present. The first is a primarily ovate dominated assemblage that was recovered *in situ*, while the second is likely to present a collection of derived tools, as has been argued for by Smith (1921a: 19). As these derived handaxes include a higher number of pointed forms, this may also explain Roe's problems in ascribing the assemblage from Caddington to a particular group (see Roe 1981: 191). Given the differences in the level of thinning seen on the artefacts from these contexts, it is probable that there are differences in the raw materials that were available, which would have influenced the knapping trajectory and, by extension, the thinning technique applied. Further exploration of the handaxes from the Palaeolithic Floor and Contorted Drift begins to suggest that this may be the case. The thicker handaxes from the Contorted Drift are generally made on sub-cylindrical nodules or spherical pebbles that appear to have limited the amount of thinning that could have been applied to these tools. On the other hand, the Palaeolithic floor assemblage displays the use of more tabular flint nodules that provided relatively thin blanks. Size of the nodule does not appear to have been a primary influence over the results, as both large and smaller handaxes are seen to cluster together.

Summary

The results from the analysis of the replica assemblage have clearly shown that the methodology is unable to detect any clear association of tools based on idiosyncrasies that provided evidence of specific knapping traits linked to individual knappers. Therefore, it is impossible to discuss the clustering of handaxes within the results from the Caddington assemblage in terms of the hominins involved in their manufacture. However, the results have highlighted a number of other issues that need to be addressed further.

The scatter diagrams produced from the analysis of the Caddington assemblage have proven to be clearly different to those seen from both the replica and Boxgrove assemblages studied. This is despite that fact that the attributes of the components produced from the principal component analysis are relatively similar. The combined assemblage from Caddington shows a greater degree of variation in the results from both the aspect and slope analysis. Distinct outliers continue to be mainly anomalous forms, such as handaxe #1431, although in the slope analysis results outlying clusters were shown to be extensively thinned ovates. This is in contrast to the results from Boxgrove, where outliers in the slope analysis were those tools that were less refined. This appears to indicate that extensive thinning of the handaxes at the Caddington brickearth pits was not a regular occurrence and that the tools studied are predominantly more angular and less intensively reduced.

More interesting, though, is the analysis of the Pit C assemblage and the discovery that the tools from the Palaeolithic Floor and Contorted Drift present clear differences in results from both the aspect and slope analysis. This emphasises the distinction between these two assemblages that has been discussed by Bradley and Sampson (Bradley & Sampson 1978) and highlights the fact that the handaxes from the Contorted Drift are likely to be derived from the surrounding area, though it is not possible to tell if they originate from the same assemblage or several separate accumulations of tools. In addition, the results of the slope analysis indicate that the handaxes from the *in situ* Palaeolithic Floor tend to cluster tightly, reminiscent of the results from the Boxgrove assemblages. It is possible, therefore, that the greater variation displayed in the analysis of the entire Caddington assemblage may have been caused by differences between tools found *in situ* on Smith's (1894) Palaeolithic Floor within each of the brickearth pits and those recovered from the Contorted Drift. Unfortunately, it is not possible to include further analysis based on this assumption. This is due to the fact that contextual information was not present for a large number of the tools studied. Even so, this assumption may also explain the limited separation of the handaxes according to which brickearth pit they were recovered from. Separation of handaxes from the same pit assemblage within the graphs may be due to differences in the context they were found in. However, further analysis of the Caddington assemblage is needed in order to support this hypothesis.

Finally, there is also the suggestion that the distinction between the Palaeolithic Floor and Contorted Drift handaxes may be due to variation in the raw materials available to the hominins involved in the deposition of these tools. As discussed above, handaxes from the Palaeolithic Floor present examples that are thinner with less angular surfaces that result from a combination of extensive thinning and the use of tabular flint nodules. On the other hand, the Contorted Drift handaxes are thicker as a result of lower intensities of thinning and the use of sub-spherical and sub-cylindrical nodules, as well as smaller flint pebbles, that appear to have restricted the amount of thinning that could have been applied. Therefore, raw material properties may also play a large role in the variance within the samples and further research into differentiating between the types of nodules available at each of the Caddington brickearth pits is required to tease apart how this factor may have both influenced the choices of hominins and hidden any possible idiosyncrasies that may have been traced by the current analysis.

FOXHALL ROAD

The handaxes from Foxhall Road studied as part of this thesis were recovered from a variety of contexts during Miss Layard's excavation (White & Plunkett 2004). Only two of these contexts produced samples of handaxes that are large enough to be considered adequate for statistical analysis. These are the grey clay and red gravel units. However, it was felt necessary to analyse the entirety of the Foxhall Road assemblage in addition to the handaxes from these contexts. As a result, the analysis of Foxhall Road is separated into three elements. First the entirety of the available Foxhall Road material is discussed as a whole. Following this, the grey clay and red gravel units are analysed as two distinct assemblages.

Analysis of the combined Foxhall Road assemblage

Aspect analysis

The results from the principal component analysis of the aspect data obtained from the handaxe surfaces from Foxhall Road are displayed in Table 7.21. A total of three components were extracted, which account for 65.31% of the variance within the sample:

- The first component shows a high correlation to the northwest variable.
- The second component, on the other hand, appears to correspond to both the north and south variables.
- The third component is strongly associated with the east and southeast variables.

As with the both the replica and other archaeological assemblages studied, the variance within the combined Foxhall Road assemblages can be mainly explained by variables related to northern and southern aspects. The high loading for the easterly and westerly variables, however, is atypical of the previous analyses. This contrast can be explained by the high numbers of twisted bifaces within the sample, which would increase the variation in both easterly and westerly orientation of the handaxe surface. Overall, however, the results appear to be primarily influenced by the shape of the handaxes themselves. As has already been mentioned, this appears to relate to the differences in butt and tip surface area between pointed and ovate tools. Given that data points from the tips of the handaxes generally have a northern aspect, while those from the butt have a southern aspect, the differences in the number of data points associated to these areas of the tools during the scanning process is likely to explain why the analysis appears to detect differences in butt and tip morphology. As a result, it is suggested that this may be a methodological issue that needs addressing in future analyses.

Table 7.22 displays the results from the analysis of the whole unit data from the Foxhall Road assemblage. Again, three components were extracted, explaining 67.56% of the variance:

- The first of these components corresponds strongly to the northwest and southeast variable.
- The second component correlates to the north and south variables.

- Finally, the third component is explained by the south and east variables.

As with the analysis of the individual handaxe surfaces, the results continue to suggest that it is variation in the variables that account for northerly and southerly aspect that explain the majority of the variance. In addition, the fact that easterly and westerly variables are strongly weighted for agrees with the results from the previous analysis and it is again suggested that this is linked to the presence of twisted bifaces within the sample.

The scatter diagrams produced from the analysis of the handaxe surface data indicate that there is limited clustering of 'genetically' associated surfaces (Figure 7.34). This continues to emphasise that there is little association between the two opposing faces of a handaxe and suggests that morphological similarity between them was not a primary concern for the knapper. Scatter diagrams of the whole unit results were created using both data produced from Roe's methodology, as well as the context information for the handaxes studied. Figure 7.35 shows that the handaxes can be separated by shape, to some extent. This is especially true of those graphs that include component one. However, there is still a high degree of overlap between ovate and pointed forms.

Figure 7.36 indicates a degree of separation based on the locations from which the handaxes were recovered. This is not overly surprising given that the majority of the tools studied come from the ovate dominated grey clay and the point dominated red gravel. Therefore, the differentiation of the handaxes based on their context may be reflecting differences in the shape of the tools. In addition, it is interesting to note that the majority of the handaxes with no fixed provenance, which were found during the 1902 season (Layard 1902, 1903; White & Plunkett 2004), tend to cluster together. This suggests that many of these tools may belong to the same assemblage, although this hypothesis cannot be adequately tested at present.

Several outliers are present in the graphs. Of these outliers, #50b, #61, #72 and #175 present individual handaxes that stand apart from the central cluster. All of these handaxes indicate limited amounts of flaking used in their production, with #50b, #72 and #175 all created by knapping small flint pebbles. There are also a number of smaller clusters of tools that stand out. Two interesting clusters are present on the left side of the scatters in Figures 7.35a and 7.36a. The first includes #42, #48 and #100b. These are all very similar in shape as well as the overall flaking pattern applied in the finishing stages of manufacture. In addition, #42 and #48 both originate from the grey clay. However, #100b, which clusters closely with #48, was recovered from the upper sand and gravel. If White and Plunkett (2004) are correct in assuming that artefacts within the upper sand and gravel truncate the main artefact horizons at Foxhall Road, then #100b may actually be derived from the grey clay. This would then suggest that this cluster occurs due to possible similarities in tool manufacture that may be idiosyncratic in origin. The second cluster is much tighter and includes #38, #106b and #132b. This cluster is very different to that previously discussed, as all the tools originate from separate contexts and comparison of the tools indicates little similarity in terms of shape and flaking patterns. This serves to emphasise that the relationships between the tools seen in the graphs is likely to be the result of other factors, as opposed to variations introduced by individual knappers.

Several other clusters continue to show tools from different contexts that group together. For example, the cluster of #49, #69b and #129 includes tools from two different contexts. In addition, these tools do not display clear similarities. The cluster including #16b, #62, #65, #69, #77b, #78b and #136 also shows tools from several different contexts grouping together. However, this cluster is even more complex, as it shows four crude pointed forms displaying limited work around the butt that cluster with three refined ovates. While tools of the same shape show some similarities within this group, the fact that they were recovered from different contexts and cluster with very varied forms reinforces that the results cannot be used to distinguish idiosyncratic knapping patterns within the assemblage.

Slope analysis

The results of the principal component analysis that was applied to the slope data from the handaxe surfaces are shown in Table 7.23. Overall, a total of three components were extracted, accounting for 84.79% of the variance:

- The first component is correlated to the variables between 35º-85º, which again accounts for increasing angularity of the handaxes.
- The second component mainly corresponds to the variables between 5º-10º, representing increased thinning.
- The third component shows no variables loaded over 0.4, but the strongest weighted variables are those between 20º-30º and 75º-85º.

These results correspond well to those recorded from both the replica and other archaeological assemblages.

Table 7.24 displays the results from the analysis of the whole unit data. Again, three components were extracted from the analysis. These three components account for 87.75% of the total variance within the sample:

- The first component correlates to all the variables between 35º-90º and is interpreted in a similar manner to the corresponding component from the previous analysis.
- The second shows no variables loaded above 0.5. However, it can be explained by the 0º-15º and 75º-85º variables.
- Likewise, component three displays no variables weighted for over 0.5, though it appears to correspond to the 20º-25º and 80º-85º variables.

Again, the results correlate well with those from previous analyses.

Figure 7.37 continues to demonstrate that there is limited clustering of 'genetically' associated surfaces. This continues to support the suggestion that each face of a tool is not necessarily similar in terms of its three-dimensional morphology, and that this aspect was not a key concern in the knappers' goals. The scatter diagrams of the whole unit results continue to emphasise the findings from the aspect analysis. When Roe's typology is used to differentiate the handaxes, the scatter diagrams clearly display separation according to differences in shape (Figure 7.38). This differentiation is most evident in the graphs comparing component one and appears to disappear when this component is removed. However, the fact that component one, which explains the majority of the variation, is correlated to differences in shape supports the idea that the form of the tools has a large impact on the results. Scatter diagrams were also created using the context information for each handaxe (see Figure 7.39). These indicate that the results cannot be differentiated based on the stratigraphic unit from which the tools were recovered and, when compared with the graphs including shape data, emphasises that the shape of the tools contributes greatly to the majority of the variance seen.

In Figures 7.38a and c, it is interesting to note that there are several handaxes that do not appear to cluster with tools of the same shape. These include the pointed handaxes #121, #128, #129 and #168, which cluster with ovate forms, and the ovate handaxes #50b and #172, which cluster with the pointed forms. The reason for these anomalies appears to be the extent to which the tools have been thinned. Those pointed forms that cluster with the ovates all tend to be thinner forms compared to the other pointed handaxes recovered. On the other hand, the two ovates are small and crude with limited thinning. This suggests that the results discussed are representative of the level of refinement applied to the tools being studied and indicates a clear division between pointed forms, which tend to be thicker, and ovates, which are generally more intensively worked.

Analysis of the Grey Clay assemblage

Due to the fact that the results of the combined Foxhall Road assemblage failed to show any meaningful clusters from the aspect and slope analysis of the handaxe surface data, it was decided that only the whole unit data from the gray clay handaxes would be analysed. This corresponds to the analysis of the Pit C assemblage from Caddington discussed above.

Aspect analysis

The results of the principal component analysis of the aspect data extracted from the grey clay assemblage are displayed in Table 7.25. Three components were extracted, explaining 75.24% of the variance in the data:

- The first component appears to be accounted for by the northwest, southeast and west variables.
- The second component correlates strongly to the north and south variables.
- Finally, the third component corresponds most strongly to the east variable.

Again, a large amount of the variance appears to be explained by the northerly and southerly variables, which is attributed to the differences in tip and butt area seen between pointed and ovate tools, although inclusion of more easterly and westerly variables is an anomaly in comparison to the replica and other archaeological assemblages studied. The main explanation for this difference is suggested to be the high number of handaxes displaying a twisted profile within this assemblage.

Scatter diagrams were created using the results from the principal component analysis and Roe's typology was used to differentiate the handaxes according to their shape (Figure 7.40). As these graphs show, there appears to be a clear distinction between pointed and ovate forms based on the results of the aspect analysis. However, there is a degree of overlap. For example, #172 clusters with the pointed forms while being ovate in shape and #65 clusters with the ovate forms while being pointed. Closer examination of these two tools shows that #172 is less refined with fewer flake scars compared to the other ovate forms in the assemblage. On the other hand, #65, while pointed in form, has a peculiar shape that is reminiscent of an ovate form, although it lacks a curved edge. It is possible that the aspect data extracted from this tool may have produced similar results to the ovate handaxes studied based on the scar patterns produced during it's creation.

In addition, there are several outliers within the data. Handaxe #61, which sits on the right hand side of Figures 7.40a and b, is a cruder pointed form displaying high values in the northwest and west variables. This is due to the removal of two large flakes along the edges of one side of the tool. Handaxe #36 and #63 also cluster and are similarly shaped small ovates. However, no clear idiosyncrasies are present that link these tools. Finally, handaxes #42 and #48 stand apart. These are both elegantly worked ovates and have been argued to be the work of the same individual (see Chapter Four).

Slope analysis

The results of the principal component analysis for the slope data are displayed in Table 7.26. Three components were also extracted from this analysis, which accounts for 91.05% of the variance:

- The first component strongly corresponds to the variables between 40°-85°. As with previous analyses, high values for this component appears to represent increasing angularity of the handaxes.
- The second component correlates to the 0°-15° variables, with the 75°-90° variables loaded slightly lower, below 0.4.
- The final extracted component is strongly associated with the 85°-90° variable.

These results are in keeping with those from the previous analyses of both the replica and archaeological material.

Again, scatter diagrams of the results were created using Roe's typology to differentiate handaxes by shape (Figure 7.41). The graphs continue to show the separation of the handaxes into pointed and ovate forms where component one is present. Figure 7.41a shows three distinct clusters, with #65 standing apart as a lone outlier. It is suggested that #65 is separated due to that fact that it displays a very flat surface on one side. Handaxes #36, #49 and #177 form a cluster nearby. These tools are all ovates with similar form. In addition, #36 and #49 display a highly comparable flake scar, which may indicate a potential idiosyncratic marker (Figure 7.42).

The other clusters present show a clear separation between points and ovates. It is also interesting to note that #42 and #48 continue to be closely linked. The cluster of pointed forms also includes #172, which is classed as an ovate using Roe's methodology. Closer examination of this tool shows limited flaking with a steep cortical section, which is suggested to be the reason for this anomaly.

Figure 7.41b continues to indicate separation of the tools according to shape and also shows that the ovate tools tend to form much tighter clusters compared to the pointed forms. Again, #42 and #48 are closely related, which emphasises the link between these tools. However, the overall suggestion of the results is that there is less variation in the ovates recovered from the grey clay when compared to the pointed forms.

Analysis of the Red Gravel assemblage

The analysis of the material from the red gravel assemblage continues in the same manner as that of the grey clay assemblage. Slope and aspect analysis was performed using only the whole unit data. This was due to the fact that the handaxe surface data produced no meaningful clusters in the analysis of the combined Foxhall Road assemblage, as discussed above.

Aspect analysis

The results of the principal component analysis of the aspect data from the red gravel assemblage are presented in Table 7.27. A total of three components were extracted, which explained 76.19% of the variance within the sample:

- The first component is strongly correlated to the north and northwest variables, with lower values for the west, southeast and south variables.
- The second component corresponds to the northeast and south variables.
- The final component that was extracted is mainly accounted for by the east variable, with minor input from the west, southeast and south variables.

The results show that variation within the northerly variables appears to explain the majority of the variance within the sample. This may be explained by the fact that pointed forms are dominant within this assemblage.

The scatter diagrams of the results were produced and Roe's typology was used to differentiate the handaxes based on their shape. As Figure 7.43 shows, the results of the aspect analysis show little differentiation of the tools according to whether they are of pointed or ovate form. There also appears to be little association between the extent to which a tool has been worked and refined and the clusters produced. For example, #106b, an intensively worked ovate, is an outlier to the central cluster. However, #157b, which is comparably worked, is found associated with less refined tools. Therefore, it appears that the results indicate variation that cannot be explained by the extent of reduction applied to the tools or their shape.

Slope analysis

The results from the principal component analysis of the slope data are presented in Table 7.28. Again, three components were extracted from the analysis, accounting for 90.17% of the variance within the sample:

- Component one is strongly correlated to the 35^o-90^o variables. Again, this is correlated to increasing angularity of the handaxes under study.

- Component two is associated with the 70°-85° variables. This may be related to the frequency of step fractures or areas of extreme angularity.
- The final component that was extracted corresponds mainly to the 5°-10° variables and indicates extensive thinning.

Compared to the results for the grey clay assemblage, the handaxes from the red gravel show that a major source of variation is found within the variables associated with higher slope angles. Again, the fact that pointed handaxes are the dominant form within this assemblage appears to explain these results.

The results of the principal component analysis were plotted as scatter diagrams using Roe's methodology to differentiate the handaxes based on shape (Figure 7.44). While the results of the aspect analysis show little clustering according to shape of the handaxes, the results of the slope analysis do indicate a degree of separation based on the form of the tools. This separation is clearest in the comparison of components one and three. However, the graph of component one and two shows that ovate forms tend to be clustered tightly, while pointed forms display much more variation. Three clusters of tools are present in Figure 7.44a. The first of these clusters is formed primarily by ovate handaxes, though one single pointed form, handaxe #168, is present. All of these tools are extensively thinned and show a relatively high degree of flaking. A second cluster, including several pointed forms (#72, #77, #103 and #170) and the ovate handaxe #50b, is made up of much cruder tools with a greater degree of variability in the extent of thinning. These handaxes display lower values for component two, which is attributed to the fact that the flint pebbles selected for reduction were thinner in profile, or that one side of the handaxe appears to have been thinned to form a much flatter surface. Finally, a third cluster is formed from five pointed tools, all of which are crude forms. The primary reason that these tools display high values for component two is the presence of large numbers of step fractures, in the case of #55b, or large, rounded cortical butts, which have lead to high numbers of data points that display very steep slope angles. All these tools were created using highly rounded flint pebbles, which appear to have greatly influenced the reduction technique that was applied. As a result, raw material appears to have played a significant role in the morphology of the tools.

Figure 7.44b displays the opposite to that previously discussed, with ovates displaying a greater amount of variation when compared to the pointed forms. This can be explained by the fact that there is more variation in extreme thinning within the ovate handaxes, whereas the pointed forms display a comparative degree of angularity across their surfaces. However, it is interesting to note that of the highly refined tools, #78b, #106b and #157b all stand apart from the others studied. In addition, #158b and #168 cluster tightly, but display no comparable idiosyncratic traits. This suggests, therefore, that clustering of tools is not necessarily indicative of idiosyncratic similarities in tool form or knapping procedure.

Summary

The results from the analysis of the Foxhall Road assemblages are very different when compared against those from Boxgrove and Caddington. Much of the variance within the sample appears to be explained by the shape of the tools studied, while there is little clustering of handaxes according to the contexts from which they were recovered. When the assemblages from the red gravel and grey clay are studied, this separation of tools based on shape continues, with the graphs generally showing much tighter clustering of ovate tools, especially where the components that explain the majority of the variance are concerned. However, a degree of overlap between pointed and ovate forms was also noted, especially in the graphs produced from the aspect analysis.

It is important to note that the artefacts from Foxhall Road indicate the utilisation of two different raw material sources. These are larger flint nodules and smaller flint pebbles or flakes. It has also been suggested that handaxes created using larger flint nodules in order to produce refined ovate handaxes took place at a different location and the resultant tools were then brought to the site, while pointed artefacts produced on smaller flint pebbles and flakes were made at Foxhall Road (White & Plunkett 2004: 150). The evidence for this is a lack of débitage from the grey clay assemblage, which contains predominantly well worked and highly refined ovate handaxes, while hard and soft hammer flakes recovered as part of the red gravel assemblage indicate that manufacture was taking place on the spot (*ibid.*). However, there are instances where ovate handaxes are also produced using small pebbles. A prime example of this would be #50b, which displays a rind of cortex that extends down the entirety of one side (see Figure 7.45). Therefore, the Foxhall Road analysis not only appears to indicate clustering due to the shape of the tools, but also suggests that raw material was a key factor that contributed to the overall variability in the sample. If raw material had a large impact on the knapping strategy applied to these tools, as has been previously argued by Ashton & McNabb (1994) and White (1998a), then the clustering of tools seen in the results can be explained by the way that raw material influenced the knapping strategy applied and ultimately the final form of the handaxes studied.

DISCUSSION AND SUMMARY

Overall, the findings indicate that the methodology is unable to trace idiosyncratic traits linked to knappers involved in the formation of the assemblages studied. However, the analyses discussed have highlighted a number of interesting points that must be investigated further. The first of these is that there is very limited clustering of 'genetically' associated handaxe surfaces. This occurred throughout all the assemblages when opposing surfaces from the same handaxe were studied separately. In addition, no pattern within the clustering of 'genetically' associated surfaces could be discerned that indicated tools produced by the same knapper. However, this disparity does appear to show that knappers did not apply symmetrical standardisation and the same degree of thinning to the three-dimensional morphology of the tools that they produce. This is an important consideration given the frequency at which symmetry of tools, especially in planform, is discussed within the literature (e.g. Le Tensorer 2006; McNabb *et al.* 2004; Saragusti *et al.* 1998). However, it is likely that the disparity between the two faces of a tool is due to the organic nature of the flaking process. As a result, further work needs to be conducted in order to align these results with the study of both planform and profile symmetry in order to truly understand the level of standardisation and symmetry that was applied to these handaxes.

The results from the analysis of the whole unit data were more informative. The outcome from the examination of the replica assemblage indicated a differentiation of the tools based upon their shape, as defined by Roe's (1964, 1968) typology, while differentiation based on shape is more complex within the archaeological assemblages. This was especially true of the aspect analysis results from the archaeological samples, which displayed very little correlation to the overall shape of the tools. However, the results of the slope analysis tend to show a more obvious segregation of points and ovates, especially within the Foxhall Road assemblage. This is also true of the Caddington assemblage, though to a lesser degree and with more overlap between the two forms. On the other hand, the tools from Boxgrove indicate no distinction based on handaxe shape. This may be explained, as discussed above, by the fact that the tools classified as points within the Boxgrove assemblages cannot be compared to classic triangular forms. Instead they are mainly cordates, which sit just over the arbitrary line that Roe used to distinguish ovates from pointed forms. Therefore, pointed handaxes within the Boxgrove assemblages often appear similar and highly comparable to handaxes that are classed as ovates.

In addition to the shape of the artefacts, the raw material choices of the knappers also appear to be a contributing factor to the overall variance seen. The evidence for this comes primarily from the site of Foxhall Road, where the differentiation of tools according to their shape occurs most strongly. Foxhall Road consists of two main assemblages; the gray clay, which is dominated by ovates, and the red gravel, which primarily consists of points. Both assemblages show a clear distinction between tools created using small flint pebbles found in the local vicinity and well-worked handaxes that were made elsewhere, primarily using good quality raw material, and brought to the site (White & Plunkett 2004: 105-21). For example, the grey clay assemblage, characterised by finely made ovates suggested to have been brought onto the site, shows several examples of both pointed and ovate tools created on small flint pebbles or flakes, such as #69 and #172 (see Figure 7.46).

Likewise, the red gravels provide evidence of finely worked bifaces amongst a primarily much cruder assemblage. Examples include #106b, an elegant ovate form, and #168, a pointed form described as a child's toy by both Evans and Miss Layard (*ibid*.: 120; see Figure 7.47). The fact that cruder ovate and more elegant pointed forms exist is important, as, when analysed, these tools tend to produce anomalous results. Using the examples above, one can see that #172 from the grey clay clusters with the much more angular and less intensively thinned pointed forms in Figure 7.41a, while #168 clusters with the extensively worked ovate tools in Figure 7.44a. Therefore, it appears that raw material plays an important role in determining the variance within the sample, as they had a large influence over the choices and decisions that the knapper was required to make during the production of a functional tool (Ashton & McNabb 1994; White 1998a).

While the assemblages from Foxhall Road shows a clear differentiation in the types and qualities of raw material used by hominins at the site, both Caddington and Boxgrove had flint of relatively uniform quality. At Boxgrove, hominins utilised mainly nodular flint that eroded out the chalk cliff face, preferring it to the tabular forms that were also available, because these were more difficult to flake (Roberts & Parfitt 1999: 356). Caddington, on the other hand, displays evidence for the reduction of both nodular and tabular flint that was of comparable quality. However, both sites also show evidence for small flint pebbles being used for the production of tools. Examples of this include #129 and #136 from Boxgrove Unit 4u, #161 and #179 from Unit 4/3, and #1602 and #1713 from Caddington. Such handaxes are also often outliers within the plots of the results, while those made using the more commonly selected flint nodules cluster together. In addition, examination of the Caddington assemblages displays a variation between the types of flint available to the knappers, especially at the Cottages Site (Pit C, Bradley & Sampson 1978: 89). Here, the Palaeolithic Floor assemblage appears to be primarily made using tabular nodules, while the Contorted Drift handaxes were made using rounded pebbles and sub-cylindrical flint nodules. This distinction in raw materials appears to explain the separation between these two contexts seen in the slope analysis, which indicates how the tools from the Contorted Drift are thicker and more angular compared to the comparatively well-thinned Palaeolithic Floor handaxes. This again emphasises that raw material choices had a strong influence over the variance seen and the morphology of the tools themselves.

The results also emphasise a level of standardisation within the assemblages studied. This is especially visible in the analyses of the two stratigraphic units from Boxgrove. Both Unit 4/3 and 4u display a dense central cluster that accommodates the majority of tools, with outliers primarily representing anomalous forms that are often produced on sub-standard raw material. Caddington also shows a degree of standardisation, though this is less pronounced. While Foxhall Road does not immediately follow this pattern, the separate analyses of the grey clay and red gravel assemblages also begin to show similar standardisation of tools. This apparent homogeneity within the assemblages is most often seen within the ovate tools present and is most greatly reflected by the plots of the results from the slope analyses, which indicates a standard level of thinning was generally applied that limits the overall angularity of the surfaces from these tools. However, in the case of the Pit C assemblage from Caddington, there is a distinction between the ovate tools from the Palaeolithic floor, which show more homogeneity than those from the Contorted Drift. This can most adequately be explained by the fact that the Contorted Drift material has most likely been transported to the site by natural causes and that this group of tools is possibly older and may even be formed from a number of separate assemblages (Bradley & Sampson 1978). In addition, the lower level of homogeneity in the combined analysis of the entire Caddington assemblage can be attributed to the fact that the sample is made up of separate assemblages from a number of different brickearth pits that formed in chalk solution hollows.

While the results from the slope analysis highlights the general homogeneity of the assemblages studied, as well as indicating a differentiation of the tools studied based on shape and raw material factors, the results of the aspect analysis appear to show other complex features. There is a degree of separation of the tools based on shape in the plots from some of the assemblages. This is generally due to the fact that more data points will be recorded for the tip of ovate handaxes when compared to pointed forms simply because the surface area in this region is greater for these tools. Therefore, higher numbers of points attributed to northerly variables are recorded for the ovate tools studied. As a result, it can be shown that the shape of the tools will contribute greatly to the variance seen within the aspect results. Therefore, it appears that the methodology applied was unable to provide a deeper level of analysis that surpasses the overall morphology to the tools and this methodological issue needs to be addressed prior to any further analysis that revolved around the aspect of handaxe surfaces. However, the aspect results do indicate a difference between handaxes that lie within a common range of variation and those that produce anomalous results. These outliers are generally those with evidence of limited flaking applied to the handaxe surface, often representing cruder tool forms, or ones with extensive flaking that conform to a particular pattern.

Handaxes suggested to be made by the same individual are also seen to cluster together. Examples of such tools include #42 and #48 from Foxhall Road and #1417 and #1419 from Caddington (Figures 7.48 and 7.49). While such results may be taken as potential evidence for idiosyncratic markers that can be linked to individual knappers, it must be remembered that the clustering of tools within the plots is more complex. Several of the clusters group together tools that display similar repeated flaking patterns with others that show large flake removals that are non comparable. An excellent example of this would be those clusters produced from the analysis of Unit 4/3 at Boxgrove. Here handaxes with similar flaking patterns along the edges of the tools clustered with cruder forms that, when compared, display single flake removals across the same area of the handaxe surface. The reason for this appears to be that both the repeated flaking and single removal techniques applied to these tools produces a comparable signature for the particular aspect variables in question. The overall effect of this serves to demonstrate that the results of the aspect analysis cannot be taken as indicative of idiosyncrasies *per se* and that the manufacture of the tools studied produces a variety of complex patterns. However, the presence of a dense central cluster within the majority of the plots produced suggests that to some extent there was a generally accepted flaking technique at the sites studied.

The final revelation from this series of analyses is that there is a great disparity in the results from the replica and archaeological assemblages. Of the archaeological assemblages studied, only Foxhall Road produced results that can be considered comparable. As the Foxhall Road assemblages show the greatest variation in raw material choice and the knappers who produced the replica assemblage were given free reign to choose the flint sources for their handaxes, it is clear that the results from the replica assemblage are a reflection of this decision. The fact that this distinction in raw material choices also reflects the shape of the handaxes serves to emphasise further the suggestion that raw material form and quality has a direct affect on the morphology of tools. In addition, this highlights the fact that the original choices made during the formulation of the replica assemblage are not an accurate portrayal of what we find in the archaeological record and draws attention to the issues in attempting to produce replications of Palaeolithic material.

In summary, the analysis of the three-dimensional morphology of handaxes was unable to identify idiosyncratic traits that linked knappers to their creations. The results produced show that there are a number of different factors that appear to explain the variance within the samples studied, including raw material, tool form and potential differences in knapping skill. These factors all serve to mask any idiosyncratic traces that might be linked to knappers involved in the production of these assemblages. In addition, differences in raw material appear to have a direct influence over tool form, often dictating aspects of the knapping sequences and constraining the choices available to the knapper. However, localised clustering of some tools within the replica and archaeological assemblages, which have been suggested or shown to be the products of the same individual, demonstrates that there is potential for continuing to seek ways to analyse the individual in Palaeolithic assemblages. Even so, these tend to be isolated incidences that occur outside of the main clusters that occur within the plots. In addition, the complexity of these clusters and the inclusion of tools that are not directly comparable in both form and flaking patterns add further uncertainty to any claims for idiosyncratic markers. What the results do suggest, however, is that patterning can be studied at the scale of the assemblage, while analysis of the individual currently proves too fine-grained for any meaningful conclusions to be formed.

CHAPTER EIGHT
TWO-DIMENSIONAL ANALYSIS OF SCAR PATTERNS

INTRODUCTION

In the preceding chapters, both the analysis of the refitting material and three-dimensional morphology of handaxes were discussed. The results so far have shown that the individual hominin remains elusive. Instead, a suite of factors appears to prevent knapping idiosyncrasies from being detected by the quantitative techniques applied. This demonstrates that discussion of the individual is fraught with difficulties. On the other hand, traits exhibited by groups of hominins may be much easier to assess.

This chapter presents the results from the final experimental methodology; namely the two-dimensional analysis of flake scar patterns. As described in Chapter Three, each handaxe was photographed and the scar pattern traced. These traces were then imported into a computer program designed to return a two-dimensional discrete Fourier transform of the image and calculate the intensity values for each five-degree segment within a 180º arc of the resultant spectrum. As a result, thirty-two variables were produced for each traced image and these were analysed using principal component analysis in order to investigate the variance further. This methodology was applied to the replica assemblage in the first instance, in order to ascertain its reliability, followed by each of the archaeological assemblages to provide a comparison. The goal of this analysis was to test the extent to which Gunn's (1975) hypothesis can be validated using more sophisticated computerised techniques. Gunn analysed a series of artefacts made by five modern knappers, each of which was required to conform to a specific shape and size. These formed an assemblage, with the addition of one archaeological sample. As suggested in Chapter Three, the fact that Gunn requested the knappers to all produce tools of similar form introduced a bias into the analysis that would not be reflected in archaeological samples. Therefore, the analysis presented here seeks to understand whether Gunn's methodology can be deemed accurate, as well as demonstrating whether the methodology can trace knappers within assemblages. However, it should be noted that the freedoms afforded to the knappers of the replica assemblage might have also introduced biases, whether wilful or accidental in nature, and such biases will be addressed within the discussion of the results.

The data presented in this chapter comprises intensity values from Fourier transform spectra produced from the analysis of scar pattern traces. The datasets for each of the assemblages can be found on the supplementary data disc at the rear of this volume. These intensity values were recorded across thirty-six variables, each of which corresponds to the orientation of lines within the scar patterns (see Figure 8.1). The higher the intensity for a particular variable, the more lines are orientated in the corresponding direction. In his experiment, Gunn suggests that the variables also correlate to the orientation of flake scars on the surfaces of the tools under study. However, as discussed in Chapter Three, scars from flakes removed earlier in the thinning and finishing of a handaxe will have undoubtedly been heavily modified by subsequent removals. Only the final flakes removed result in scars that have not been truncated in some way and provide an accurate indication of flake scar orientation. Therefore, the variables under study should not be equated uncritically with the orientation of flake scars across the surface of the handaxes, as high values for a certain orientation may be due to the pattern of multiple removals produced by complex overlapping reduction, as opposed to a distinctive pattern of flakes detached in a particular direction. However, the results will allow discussion of overall flake scar patterning within handaxes being studied and compared. This can be used to demonstrate whether each knapper produces an idiosyncratic flake scar pattern, which may be due to a frequently used knapping strategy. However, if this is not the case, then the factors that cause knappers to modify and redirect their method of reduction will be explored.

This chapter itself is broken down into four sections. The first will discuss the application of the methodology to the replica assemblage and will demonstrate whether the analysis is able to trace the knappers involved in the production of these tools. The remaining three address the archaeological assemblages from Boxgrove, Caddington and Foxhall Road respectively. Regardless of the methodology's ability to trace individuals within the replica assemblage (or not), it is necessary to analyse the archaeology to draw comparisons between Palaeolithic artefacts and modern replications.

THE REPLICA ASSEMBLAGE

The methodology outlined in Chapter Three was applied to all twenty-six of the handaxes from the replica assemblage. The scar patterns from both sides of each handaxe were traced and analysed. Also, in order to explore the scar patterns across the tools as a whole, an averaged output for each tool was produced. In both cases, analysis was conducted using principal component and cluster analysis, the results of which were explored to determine whether the handaxe grouped according to the individual who had created them, or due to other factors.

Results from the surface data

The principal component analysis of scar pattern data from the handaxe surfaces resulted in the extraction of five components with eigenvalues greater than 1.0 (Table 8.1). These components account for 81.44% of the total variance and are correlated to the variables under study as follows:

- Component one equates to variation in most of the variables except those corresponding to horizontal and vertical orientations, with especially high correlation to variables that relate to left orientation of lines within the traces.
- Component two, on the other hand, is associated to variation in horizontal and vertical orientations.
- Component three also correlates to variation in vertical orientations, with some weighting for variables related to left orientation.
- Components four and five contribute much less to the overall variation. However, they are mainly associated to variation in the right horizontal and right centre respectively (see Figure 8.1).

To explore the results further, these components were plotted as scatter diagrams. Roe's typology was used to differentiate between pointed and ovate forms (Figure 8.2). This displays a clear division based on outline morphology when components one and two are compared, suggesting that these components are simply highlighting the *overall shape* of the handaxes, rather than differences that result from knapping idiosyncrasies. Though this distinction disappears when the other components are factored, it is notable that ovate tools continually cluster together, while pointed forms remain spread out. This suggests a higher degree of variation within the pointed tools. Furthermore, while clustering of opposite surfaces from the same tool is not prevalent, it is more common amongst ovate tools, suggesting some degree of similarity in scar patterning on the two surfaces of these tools. However, the fact that the majority of the handaxes show little clustering of 'genetically' associated surfaces demonstrates that many of the tools display differences in the progression of the thinning strategy applied to each face.

Hierarchical cluster analysis was applied to the results of the principal component analysis to determine whether handaxes clustered according to the knappers who produced them. Figure 8.3 displays the results that produced six groups. These indicate that clustering mainly results from differences in overall shape. Clusters appear to be highly reliant on components one and two, with the scatter diagrams containing these showing the greatest correlation to the clusters produced. Where other components are concerned, the clusters tend to show much greater overlap, suggesting that these do not contribute greatly to the formation of the groups. It is, therefore, highly unlikely that the cluster analysis was able to correctly group the products of the various knappers. Instead, it appears to detect the shape of the handaxes, which appears to play a large role in guiding the knapping strategy.

Scatter diagrams revealing the identities of the knappers facilitate more meaningful interrogation of the results (Figure 8.4). These show quite clearly that the cluster analysis was unable to group the tools according to the knappers who produced them. There appears to be no clearly defined separation between the knappers, with significant overlap between each knapper's tools. However, it is interesting to note that the handaxes produced by Knapper 1 always tend to be grouped together, which may indicate an element that may be linked to them specifically. However, given that the results of the principal component analysis show that the majority of the variance can be explained by differences in the shape of the tools, this may simply suggest that this knapper produced tools that are relatively similar in form.

Results from the combined data

The combined data from the replica assemblage was treated in the same way as the surface data using principal component analysis. However, the results show the presence of negative eigenvalues, which may highlight problems with the analysis. This is attributed to the fact that the number of cases (n=26) is lower than the total number of variables (n=36). As a result, the analysis can only be tentative, though the results are in agreement with those from the surface data. The analysis extracted five components with eigenvalues greater than 1.0 (Table 8.2), which account for 89.04% of the total variance within the sample:

- The first component relates to the majority of the variables, although those that correlate to left orientations display the heaviest weighting.
- Component two can be attributed to variation in variables corresponding to both horizontal and vertical orientations. This is comparable to the results from the surface data.
- Component three is also associated with variability in the vertical variables.
- Finally, components four and five show variation in right orientations, though both contribute much less to the overall variance. Again, these appear very similar to the components from the surface data.

The results of the principal component analysis were plotted as scatter diagrams that include typological data (Figure 8.5). These retain a separation between pointed and ovate forms. This is particularly evident in the diagrams that include component one and, to a lesser extent, component two, suggesting that these components can be correlated with variation in the shape of the tools. The tendency for ovate handaxes to cluster tightly is also evidenced.

Hierarchical cluster analysis was used to explore whether the handaxes could be differentiated according to knapper. Scatter diagrams resulting in six groups are presented in Figure 8.6. These continue to show that the clusters appear to be based on differences in shape and are more defined in scatter diagrams containing component one, whereas a higher degree of overlap between the clusters is seen in the remaining scatter diagrams. This suggests that component one may correlate to the shape of the tools. However, none of the clusters appear to suggest differentiation of the tools according to the knapper who produced them.

The suggestion that the cluster analysis is unable to trace individuals is confirmed when the identities of the knappers are mapped onto the scatter diagrams (Figure 8.7). However, the products of Knapper 1 still cluster throughout many of the diagrams, appearing strongest where components four and five are concerned. This contrasts slightly with the analysis of the surface data, where clustering of Knapper 1's tools was present to some extent throughout the majority of the diagrams. This may suggest that these components, which represent much smaller contributions to the overall variance, may be important in determining the identities of knappers within an assemblage. However, as the products of the other knappers do not cluster, even when these components are included, it is more likely to reveal similarities in the scar patterns produced by Knapper 1's thinning strategy.

Summary

The analysis of the replica assemblage indicates that variation within and between scar patterns is complex. This is evident from the extraction of five components that explain the largest proportion of the variation. However, the majority of the variance appears to be limited to differences in shape. Distinct divisions between pointed and ovate forms, especially where components one and two are concerned, can be seen within the scatter diagrams from the analysis of both the surface and combined data. The use of

Roe's system emphasises this separation, clearly indicating that shape is a primary factor in the scar pattern variation.

In addition, the results of the cluster analysis are primarily influenced by components one and two, suggesting that variation in shape was again the underlying factor in the formation of the clusters. As a result, the cluster analysis was unable to correctly group tools according to the knapper who made them. This is confirmed when the results of the cluster analysis are compared with the known identities of the knappers.

It is also notable that components four and five account for variation in the presence of right orientated lines within the results of both the surface and combined analyses. However, the fact that this variation contributes no more than ~10% of the overall variance indicates that any preferential selection for the orientation of flake removals suggested by the prevalence of right orientated lines within the traces does not contributed greatly to the complexity of the sample. Reading the scatter diagrams involving components four and five, it is clearly pointed handaxes that generally display the dominance of a specific orientation. On the other hand, ovate handaxes tend to show no orientation preference. This is probably caused by differences in the knapping strategy applied to these two types of handaxe (see Figure 8.8). Ovate tools are manufactured using a circumferential reduction strategy, resulting in a higher variation in flake scar orientation. The greater degree of thinning seen on these tools increases the number of flake scars seen on the handaxe surfaces. As a result a greater combination of line orientations is seen within their scar pattern traces. Pointed tools, on the other hand, tend to show a relatively high level of thinning applied to the tip, whereas the butt often displays limited working. As a result, pointed tools often show a lower variability in the orientation of lines within their traces due to the limited number of removals. This may lead to one orientation dominating the others. If this is correct, then the desired form of a handaxe will, to a certain extent, dictate the scar pattern present on the finished tool. This would explain why the results are strongly correlated with shape.

Despite the methodology appearing to detect variation in shape rather than separating the handaxes based on their knappers, the results have revealed some issues for further consideration. The first of these is that the ovate tools in the assemblage cluster together much more tightly compared to pointed forms. This indicates that the pointed handaxes display a greater degree of variation, both in their morphology and the flake scars evident upon their surfaces. In addition, clustering of 'genetically' associated surfaces (i.e. those belonging to the same handaxe) is also interesting, and may indicate similarity between the scar patterns on either side of these tools. However, the fact that the majority of associated surfaces display limited clustering indicates that scar patterning is often different on each side of a handaxe. If this is the case, it is likely to be explained by differences in the reduction of each surface and suggests that knappers do not apply identical thinning techniques to both faces of their tools.

Finally, the clustering of Knapper 1's tools within the scatter diagrams is highly interesting. Further exploration of the scatter diagrams shows that Knapper 2's handaxes also cluster to a limited extent, which is confined to the comparison of components four and five (Figure 8.7j). While this does not immediately differentiate the handaxes produced by these two knapper from the rest of the assemblage, it does suggest conformity to a specific shape and pattern of reduction that is not readily apparent amongst the products of the other knappers. However, it should be noted that these two individuals contributed the most handaxes to the assemblage. Therefore, it is possible that a bias in the construction of the assemblage prevents such patterning being seen amongst the other knappers due to the fact that these individuals contributed lower numbers of tools.

Overall, the results demonstrate the failure of the technique to trace idiosyncratic patterning within flake scarring present on the tools studied. The reasons for this are suggested to be the heavy influence of shape in governing and restricting flake scar morphology and, by extension, the reduction techniques used. While it is understood that each individual knapper will contribute to the variation within the sample according to the choices that they have to make throughout handaxe manufacture, it appears that these choices are not so much reflections of the individual's abilities, *per se*. Rather they are made in response to the desired shape of the end product. As a result, shape dictates the flake scar pattern more than idiosyncrasies within a knapper's own reduction strategy. However, the fact that Knapper 1's tools show a high degree of similarity suggests that preference for a specific shape and, by extension, a learned reduction strategy may delineate the final form of some tools.

THE ARCHAEOLOGICAL ASSEMBLAGES

Despite the methodology's failure to attribute the replica handaxes to their respective knappers, it is important to highlight both similarities and differences between the replica and archaeological material. Therefore, the methodology was applied to assemblages from Boxgrove, Caddington and Foxhall Road. As hierarchical cluster analysis was unable to group tools according to their knappers, this technique was removed from the study of the archaeological assemblages. However, the use of Roe's typology was maintained in order to determine whether handaxes display any differentiation based on shape. In addition, variables such as site and context were used to aid the interpretation of the results where applicable.

BOXGROVE

Handaxes from both Units 4/3 and 4u were studied. These assemblages were analysed separately, as well as combined to explore differences between the two samples. In each case, both individual surfaces from each handaxe and combined data representing scar patterning across the entirety of each tool were analysed using principal component analysis.

Boxgrove Unit 4/3

Analysis of surface data

All fifty handaxes selected for study from Unit 4/3 were analysed. The principal component analysis of the surface data extracted a total of three components with eigenvalues grater than 1.0. These explain 83.45% of the variation (Table 8.3):

- The first component is comparable to the results from the replica assemblage. It is associated to the majority of the variables, with the highest weighted (>0.9) variables accounting for left and right central orientations.
- The second component corresponds to horizontal orientations, with the left horizontal variable having the strongest weighting.
- The final component is also weighted for horizontal, as well as vertical orientation, though the latter is to a much lower degree.

These components were plotted as a series of scatter diagrams (Figure 8.9). Typological data was used to divide the tools into points and ovates to show whether tools grouped according to shape. As the scatter diagrams show, there appears to be little differentiation due to overall shape throughout all of the plots. However, handaxes classed as points within this assemblage generally do not display scores below .30 and most cannot be considered to be classic points. Even so, it is interesting to note that differences in shape do not appear to explain the variation within the sample. While this is in contrast to the replica assemblage, the results appear to correlate with those from the analysis of three-dimensional morphology seen in Chapter Seven, emphasising that the majority of the Unit 4/3 handaxes are very similar.

The scatter diagrams also display virtually no clustering of surfaces related to the same handaxe. This is comparable to the replica assemblage, though clustering of 'genetically' associated surfaces appears to be much lower in the Unit 4/3 assemblage. It is also interesting to note that surfaces that cluster together show no similarity in respect to their shape. Instead, across all the diagrams, there is a dense central cluster, which incorporates the majority of the handaxe surfaces. Surfaces that do not cluster within this central group form a series of outliers. A visual study of these outliers indicates a common theme: the majority display lower numbers of flake scars and/or have a larger surface area of residual cortex. The presence of cortex and lower numbers of flake scars is taken to indicate reduced working intensity on these tools. These outliers also incorporate smaller, relatively well-refined tools, as well as larger cruder artefacts (Figure 8.10). Yet it should be noted that cruder handaxes with lower intensities of reduction, such as #199, are also seen within the central cluster (see Figure 8.11). Therefore, the results do not appear to be indicative of differences in knapping skill. However, it is proposed that the lower the degree of flaking that is applied to the tool will in turn lower the variability in flake scar orientation present on the tool. If this is the case, then a dominant orientation may appear within the scar pattern trace that is different to the rest of the assemblage, resulting in the appearance of these outliers. Surfaces contained within the central cluster that display lower numbers of flake scars may occur if the overall orientation of the lines in the scar pattern is comparable to that seen in the other tools. However, further analysis of the flake scar patterning within the assemblage is needed to confirm this hypothesis.

Analysis of combined data

The analysis of the combined data from Unit 4/3 also produced three components with eigenvalues greater than 1.0 (Table 8.4). These correspond to 89.72% of the total variation within the sample:

- Again, the first component is associated to all the variables, although it is strongly weighted for the left and right central orientations. Given the results from the surface data, this component appears to correlate to the overall intensity of thinning applied.
- The second component comprises a much lower amount of the variance and appears to correspond to left horizontal orientations.
- Finally, the third component is weighted for horizontal and vertical orientations.

The results from the principal component analysis were plotted as scatter diagrams, using Roe's system (Figure 8.12). The graphs correlate well with those from the analysis of the surface data. Again, outlying handaxes are those that display either lower numbers of flake scars or extensive cortex retention, reflecting a lower intensity of flaking. The hypothesis that a lower intensity of flaking results in the presence of a (perhaps illusory) dominant orientation appears to be supported. This is most clearly seen with #172 and

#179 (Figure 8.13). Where component two is concerned, these two handaxes appear at opposite ends of the scatter diagrams. When the scar pattern traces are viewed, it is clear that #172 displays more vertically orientated lines, while #179 displays higher numbers of lines orientated within the left horizontal.

It therefore appears that the analysis may have detected differences in the thinning strategies applied to the Unit 4/3 handaxes. The fact that the majority cluster toward the centre of the scatter diagrams suggests that there was a common reduction strategy that involved high intensity thinning. Where handaxes form outliers they display alternate thinning strategies, which mainly involve the removal of lower numbers of flakes and/or retention of large areas of cortex. However, this is not a total solution and takes no account of differences in knapping skill: cruder tools also appear within the central cluster and there is a combination of relatively well-worked and cruder tools amongst the outliers. It is also notable that handaxes which cluster to the left of the scatter plots incorporating component one are all smaller tools. Thus, size may also be an important factor when considering the reduction strategy used and the amount of thinning that can be applied. Where cruder tools are concerned, there is evidence for lower levels of skill, such as thicker end products, irregular morphologies and poor control over the thinning process (Newcomer 1971; Winton 2005). While one single explanation for these outliers is not forthcoming, it is clear that they represent artefacts that do not conform to the rest of the assemblage.

Boxgrove Unit 4u

Analysis of surface data

All seventy handaxes from Unit 4u were analysed. Principal component analysis was applied to the surface data, which extracted two components with eigenvalues greater than 1.0. These account for 87.99% of the variation within the assemblage (Table 8.5):

- The first component is weighted for the majority of the variables and appears to relate to overall flaking intensity. It is most heavily influenced by variables that account for both left and right orientations.

- The second component accounts for a much smaller amount of variation, correlated to variables that represent horizontal orientations.

A scatter diagram of the results was created, with handaxes differentiated using Roe's typology (see Figure 8.14). This diagram appears to show two denser clusters, as well as a number of outlying points that generally display lower values for component one. These will now be discussed.

The two denser clusters are interesting. Cluster C1 contains handaxes with a slightly higher number of vertically orientated flake scars. Cluster C2, on the other hand, encompasses tools that display scar patterns that include higher numbers of lines orientated in a horizontal direction. At first, it might be tempting to suggest that these clusters might correlate to the artefact distribution seen in Unit 4u (see Pope 2002: 196-7), which may lead to interpretations based on the time frame in which groups of artefacts were deposited and suggestions of subtly difference group activities. However, while the two clusters initially appear to be discrete, the surfaces of several handaxes are noted to grade between them. For example, the bottom surface of #103 is found in C1, while its counterpart is found in C2. Therefore, these do not represent two distinct groups. Yet it must also be noted that while some tools grade between these two clusters, others do not and are firmly situated in one cluster or the other. Also, while C2 contains the majority of the handaxes classed as points using Roe's typology, a comparison of the tools contained within both clusters shows that there are no discernable differences in terms of their overall shape. In addition, the values from the typological analysis indicate that there is little difference between the pointed and ovate tools, with only two of the handaxes displaying values below 0.3.

While an explanation for these clusters is difficult, they appear to indicate differences in the thinning strategy applied that, in turn, affects the scar patterning on the finished tools. They also suggest that knappers can apply different thinning strategies to alternate sides of the same handaxe. This, of course, presents a significant issue with regards to any attempt to trace individuals within an assemblage.

The outlying points on the scatter diagram appear to represent handaxe surfaces that have either low numbers of flake scars, or significant cortex retention. This is comparable to the outliers seen in the analysis of Unit 4/3. The fact that these surfaces form outliers is suggested to be due to limited variation in the orientation of the lines in the scar pattern traces. This would also explain why these surfaces display lower values for component one, which is weighted for both left and right orientations. Due to the lower number of flake scars compared to other tools in the assemblage, the outlying handaxes display less complex scar patterns and, therefore, do not register multiple different orientations when analysed.

As already discussed, an explanation for the occurrence of lower numbers of flake scars and presence of cortex retention is difficult. The cluster of tools in the upper left quadrant of the scatter diagram are all smaller ovate handaxes, but show a relatively high degree of refinement with few examples of errors. The other outliers are cruder and either very small, or much larger than the other tools in the assemblage. Both of these types of handaxe display limited reduction, usually employing a low number of removals to thin the surface. Yet differences in refinement mean that poor knapping skill cannot explain all of these outliers.

Analysis of the combined data

The principal component analysis applied to the combined data resulted in the extraction of two components with eigenvalues greater than 1.0. These account for 92.59% of the total variation within the sample and are similar to those extracted from the surface data (Table 8.6):

- The first component displays weighting for the majority of the variables, especially those associated to right and left orientations. Again, the results from the surface data suggest that this component correlates to the overall intensity of thinning applied.

- The second component is weighted for variables associated with horizontal orientations and explains a much smaller amount of the variation.

A scatter diagram comparing the extracted components and including typological data is provided in Figure 8.15. This is highly comparable to that produced from the surface data. However, it is apparent that the two clusters evident in the surface data have now combined, though there is a distinction between tools that have slightly lower or higher values in component two. Given that component two is weighted for the horizontal variables, this suggests a division based on the number of horizontally orientated lines present within the scar pattern traces from these handaxes. This could be used to argue that there are differences in the knapping strategies being practiced within the Unit 4u assemblage. Whether this is linked to the patterning seen in artefact distribution within the stratigraphic unit is unknown and cannot be determined without further analysis and the required data being made available. Therefore, this hypothesis requires further testing before it can be accepted. In addition, the analysis of the surface data shows that the two sides of the same handaxe can display very different flake scar patterning, which suggests that this interpretation may be flawed.

Combined assemblage (Units 4/3 and 4u)

To determine whether there are any differences between the two Units from Boxgrove, a separate analysis was conducted on all 120 handaxes from both assemblages. Only the combined data from the handaxes was used, as the previous analyses of the individual assemblages have shown that the results from this data are generally comparable to those produced from the surface data.

The principal component analysis extracted a total of two components with eigenvalues greater than 1.0. These explain 90.61% of the total variance within the sample (Table 8.7). The two components are very similar to those produced from the analysis of Unit 4u and 4/3.:

- The first component is weighted for the majority of the variables, though the strongest correlations are for left and right orientations. This again seems to reflect the flaking intensity of the handaxes studied.
- The second component accounts for a much smaller amount of the variance and can be associated to horizontal orientations.

Scatter diagrams including shape and geological context are presented in Figures 8.16 and 8.17. These show a dense central cluster that contains the majority of the handaxes. This is surrounded by a number of outliers, mainly found within the left half of the plot. Figure 8.16 indicates that there is little differentiation between tools based on shape. As has already been mentioned, the majority of the tools classed as pointed are not classic triangular forms and are generally comparable to the ovate handaxes. It is probable that they have been classed as points due to subtle differences in their outline morphology, resulting in misclassification when Roe's typology is applied.

Where the contextual information is used to differentiate the tools, there is a notable difference between Unit 4/3 and 4u (Figure 8.17). While there is no definite separation between the two units, handaxes from Unit 4u that sit within the central cluster show a greater degree of spread compared to those from Unit 4/3, which form a much tighter group. In addition, the majority of the outliers within the scatter diagram are associated with Unit 4u and display a greater degree of variation compared with outliers associated to Unit 4/3.

When the outlying points are examined in more detail a number of different clusters can be identified. Cluster C1 encompasses a number of smaller, cruder tools that show little similarity to the majority of the assemblage. They are generally around 50mm in length and exhibit a low intensity of flaking, which may be due to their size. All of these tools originate from Unit 4u. Cluster C2 also contains smaller handaxes, but these display a higher intensity of flaking and control in the thinning strategy applied. Cluster C3 is also comprised of smaller tools, which are all very similar in both size and shape. Even the single pointed handaxe is very similar to the other tools within this group. The majority of these handaxes have a high standard of thinning applied to them. Again, all these tools originate from Unit 4u.

Two further clusters also appear. Cluster C4 contains four tools of comparable ovate shape displaying relatively extensive flake removals. Despite this, all of these tools are relatively refined and cannot be considered cruder implements. Cluster C5 contains a greater number of tools, with the majority from Unit 4u. All of these are large, elongated ovate or teardrop shaped artefacts, with most exhibiting large flake removals extending across the face of the tools. While some display high incidences of step and hinge fractures, most are well thinned.

It appears that these outlying groups do not compare well with the rest of the assemblage. While some of them are cruder tools, others are more refined. As a result, the analysis cannot simply be detecting differences in knapping skill. This argument is strengthened considering that several cruder handaxes are found at the centre of the main cluster. Nevertheless, whatever the cause for these outliers being present, it can be concluded that they present examples of artefacts that do not conform to the overall scar patterning present on the majority of the handaxes under study. Also, given that cruder and more refined tools can either stand as outliers, or be grouped with the rest of the assemblage, suggests that more factors are involved in the formation of scar patterns than the knapper alone that, as yet, cannot be accounted for. As a tentative interpretation, it is suggested that there was a greater variety in selection of nodule size and a wider range of knapping skill present during the deposition of Unit 4u. As the raw material does not differ much between the two units studied, it is possible that this may represent a slight change in hominin behaviour or the group present involved in the production of these handaxes. However, this requires further investigation before a firm conclusion can be presented.

Summary

The results from the Boxgrove assemblages present a significant departure from the replica assemblage. The variance appears to be less complex than that seen amongst the replica handaxes. This is due to the extraction of lower numbers of components from the Unit 4/3 and 4u data, compared with the five components extracted from the replica assemblage. Why this is the case is unclear, but it highlights that the replica assemblage cannot be considered a reliable analogy to what occurs at Boxgrove.

As the analysis of the replica assemblage was unable to associate the tools to their respective knappers, no argument can be put forward to suggest that the patterning seen is the result of idiosyncrasies that relate to the actions of specific individuals. In addition, the recurrent presence of a dense central cluster that contains the majority of the handaxes implies that this is not the case. Whether handaxes tend to cluster together due to a common method of reduction is unclear and requires further investigation. However, the fact that the tools cluster around the origin in the scatter diagrams shows that their scar patterns generally do not show a strong preference for a specific orientation. This may be caused by the shape of the tool, as suggested by the replica assemblage. Given that the majority of the tools recovered from Boxgrove are ovates, thinning of the surface will occur as the knapper continues to rotate the handaxe in a circumferential fashion. In addition, the higher intensity of thinning seen on the majority of the Boxgrove handaxes will increase with the number of flake scars present. As a result, a particular preference for flake orientation is lost.

However, the outliers display incidences where tools do not conform to this standard pattern. Where cruder tools are seen, it appears that poor knapping skill may provide an explanation for differences in the flake scar patterns. Yet other tools display relatively high standards of control over the thinning process and lower incidences of knapping mistakes. Where this occurs, handaxes appear smaller in size. Therefore, size may also be a contributing factor, with smaller tools requiring limited thinning, so that they are not overly reduced. As a result, a dominant orientation may have been introduced to their scar patterns. Whether this is indicative of idiosyncrasies on the knappers' part, or results from modification of the reduction strategy to accommodate size is unknown.

In addition, there are larger tools that also display dominant orientations within their scar patterns. These tools typically display larger flake scars, indicative of attempts to extend flakes across a larger area. The use of such large flakes results in more raw material being removed, meaning that extensive flaking is not required to thin the tool. Therefore, these tools display lower incidences of flake scars, which in turn leads to the appearance of a dominant orientation.

It is apparent that intensive flaking during reduction leads to extensive overprinting of flake scars, resulting in more complex patterning. This, of course, may highlight a potential issue with the methodology in regards to its ability to identify individual knappers, especially since variation in raw material can redefine the knapper's reduction strategy. As a result, it is entirely possibly very different scar patterns could be related to the same knapper, with these differences introduced due to things as subtle as the size of the nodule or the quality of the flint utilised.

All of the above hypotheses for the occurrence of these outliers are tentative and require further analysis before they can be stated with any degree of certainty. However, what is clear from the analysis of Boxgrove is that most tools conform to a similar flake scar pattern and tools that deviate from this do so due to a complex suite of factors. These may include size and shape of the end product, variation in knapping skill and differences in the raw material selected, though the flint seen at Boxgrove can be generally considered homogeneous and of good quality.

CADDINGTON

All sixty-one handaxes selected for study from the Caddington brickearth pits were analysed. The artefacts were combined into one assemblage to determine whether any differences were present at the assemblage level. In addition, a separate analysis of handaxes associated to Smith's (1894) Pit C was performed. This allowed differences between the artefacts from the Palaeolithic Floor and Contorted Drift to be explored. In both cases the surface and combined data was analysed.

Combined Caddington assemblage

Analysis of surface data

The principal component analysis applied to the surface data extracted just two components with eigenvalues greater than 1.0. These components explain 91.85% of the total variance within the sample (Table 8.8):

- Component one is heavily weighted (>0.9) for all variables expect those that correspond to horizontal and vertical orientations. This reflects the overall intensity of flaking seen on the handaxe surfaces.
- Component two explains a much lower percentage of the variance in the sample (<3%) and corresponds to the variables associated with horizontal and, to a much lesser extent, vertical orientations.

The results from the principal component analysis were plotted as scatter diagrams. Handaxes were differentiated according to their shape, as well as the brickearth pit that they were recovered from. As Figure 8.18 shows, there is little evidence for separation of the tools on the basis of their shape. However, a number of clusters appear. When the brickearth pits are used to differentiate the tools, these clusters seem to correspond, to a certain extent, to the locations from which the handaxes were recovered (Figure 8.19). There also appears to be slight separation between individual pits, with the majority of tools from Pit C situated on the right of the scatter, while tools from Pit A are found on the left. However, there is a large degree of overlap, which suggests that differences in the locations from which the tools were recovered are not the sole explanation for this pattern.

Closer examination of the scatter diagrams shows that clustering of 'genetically' associated surfaces is not especially prevalent. This correlates with the findings from both the replica assemblage and Boxgrove and supports the argument that knappers did not use the exact same thinning strategy on both sides of their tools. However, there are some instances where the scar pattern traces from each surface of the same tool are grouped closely together. The best examples are #1639, which is a distinct outlier, and the five handaxes within cluster C1 (#1398, #1416, #1468, #1583 and #1598). It is also worth noting that #1416 and #1468 were suggested to be the product of the same knapper by Bradley and Sampson (1978) based on their similar morphology and raw material provenance. While it is possible that such a supposition is accurate, especially given the results from the visual analysis of the replica assemblage in Chapter Five, the is not enough evidence to support that these tools were related to the same individual, and I am inclined to believe that their similarities are not as distinct as other handaxe pairs, such as those from Foxhall Road.

To examine the results in more detail, the scatter diagrams were broken down into a series of distinct clusters. The first of these (C1) contains four ovate handaxes and one point, all of which are small and display a relatively low intensity of flaking. The tools from Pit C (#1416 and #1468) appear fresh and suggest a higher level, while those from Pit A are more abraded (See Figure 8.20), though they are recorded as being *in situ* (Smith n.d.). All of these tools appear to have been made on either small cortical pebbles or tabular blanks.

The second cluster (C2) contains nine handaxes. Again, the majority are ovates, with one pointed form also present. There is a mixture of abraded and fresh artefacts displaying a low degree of thinning, though some examples show a much higher intensity of flaking. All of the tools are relatively small and considered to be made on small pebbles and tabular blanks. In addition, tools show both skilful and cruder knapping (see Figure 8.21). As with C1, these tools appear to have been made on small tabular blanks or flint pebbles.

Cluster C3 contains a much wider variety of tools, with cruder and more refined handaxes present, as well as both rolled and fresh tools (Figure 8.22). It can arguably be broken into two groups, although 'genetically' associated surfaces are seen to spread throughout this cluster. Therefore, such a separation cannot be considered to indicate two distinct groups. However, it is notable that the lower half of the cluster contains tools that are generally larger in size and show more intensive thinning. On the other hand, the upper half contains smaller tools that are generally well worked, though several handaxes can be considered cruder, with some clearly made on flint pebbles, such as #1478.

Finally, there are a number of outliers. Handaxe #1639 is clearly different to the rest of the assemblage (Figure 8.23). This tool is much smaller and displays a much lower intensity of thinning across both surfaces. The presence of cortex on both sides suggests this was produced on a small pebble. The group of tools found towards the top of the diagram show a much broader spread compared to the other clusters. It contains a variety of handaxes that display a predominance of horizontally orientated lines within their scar pattern traces. These tools include both fresh and rolled examples that generally show lower intensity but controlled thinning, though there are also examples of cruder artefacts. Also of note are two very refined ovates (Figure 8.23) that cluster closely, but appear very different to the majority of the tools within this group. Visually, it could be argued that the same hand created these tools, though handaxe 1729 is recorded as recovered from the Contorted Drift, while precise contextual information for #1659 is not available.

An explanation for the variation present within the scatter diagrams is elusive. The fact that 'genetically' associated surfaces generally do not cluster is suggested to be indicative of differences in the thinning strategy applied to the opposing face of each tool. This is important, as it reflects an ability to adapt the thinning strategy for each side of a tool. At the same time, it has consequences for any study of the individual, making attempts to trace knappers all the more difficult. The clustering present within the diagrams appears to reflect, at least to a certain extent, differences in raw material acquisition, though it is suspected that this is not the sole reason that the tools group in this manner. In addition, the fact that there is a differentiation between the different brickearth pits from which the artefacts were recovered is of interest and the reason for this division requires further exploration beyond the scope of this study. However, this division may be due to differences in the available raw materials at these locations; that the knappers at each location approached the reduction strategy in subtly different ways; or that differences in knapping skill may have contributed to the variance. In addition, there is the issue of whether the artefacts were recovered from the Contorted Drift or Palaeolithic Floor. While this has been taken into account for the Pit C assemblage (see below), it was not possible to study the entire assemblage in this manner due to insufficient sample size. It is considered highly probable that a combination of all of these factors will have had an influence over the formation of the Caddington assemblages.

Analysis of the combined data

The principal component analysis applied to the combined data extracted a single component with an eigenvalue greater than 1.0 (Table 8.9). This component alone accounts for 92.64% of the total variance within the sample and is weighted for all the variables under study. Again, this appears to be related to the overall flaking intensity. To enable further analysis, a second component was forcibly extracted, which has an eigenvalue approaching 1.0. This explains only 2.65% of the total variance and is weighted for horizontal orientations.

Again, scatter diagrams were produced, including information relevant to shape and location of recovery (Figures 8.24 and 8.25). These diagrams correlate well to those produced from the surface data. Several distinct clusters can be seen and many of these correlate to those discussed above, though the combination of the surface data reveals further clustering that is considered significant. These additional clusters are addressed below.

The third cluster produced in the analysis of the surface data now clearly forms two separate groups. Cluster C3[1] includes a series of larger tools that are generally more intensively flaked and appears to indicate a high level of skill. However, some handaxes still retain a large amount of cortex, while others display lower numbers of larger flake scars. The majority of the tools are ovates, though three pointed handaxes are also present. Three of the brickearth pits are represented (A, C and G) and tools from these pits do not display a large degree of overlap.

Cluster C3[2] contains a total of ten handaxes, with a variety of pointed and ovate forms that display both high and low intensity flaking. Both crude and refined tools are present. The majority of the handaxes are smaller than those in cluster C3[1] and all display some degree of cortex retention. The cluster mainly includes tools from Pit C. However, a single handaxe from Pit A and E are present and these show no clear separation from the other tools in this group.

Cluster C4 contains four tools from Pit A, C and F, all of which are relatively crude implements, though #1766 does show a higher degree of flaking on one side. All of these tools appear to have been produced from sub-spherical or sub-cylindrical flint nodules through the removal of large flakes. Cortex retention is also high amongst these handaxes.

Cluster C5 includes a mixture of pointed and ovate forms, the majority of which are well worked. Handaxe #1563, however, is a much cruder tool, displaying large, deep flake scars and a much thicker profile. Handaxe #1729 could also be considered as a cruder implement, though the flake scars present arguably attest to the use of a controlled thinning technique. However, the fact that these two cruder forms are attributed to Pit A and C, while the remaining tools were recovered from Pit E and F indicates some separation between these and the more refined tools present in this cluster.

Finally, cluster C6 contains only three tools. Two of these are finely worked ovate handaxes from Pit F, while the third is a thicker, pointed form displaying larger flake scars and a much lower intensity of thinning. As mentioned in the analysis of the surface data, the two ovate tools are potentially the product of the same hand. However, contextual data to support such a suggestion is lacking. In addition, the fact that they cluster with a tool that shows very little similarity to them, both in form and the level of thinning applied may suggest that this is not the case.

In addition to these clusters, there are a number of outliers. These can mainly be associated with Pit E and F, though some tools from both Pit A and C figure amongst them. Handaxe #1639, as has already been mentioned, is very different to the rest of the tools studied. Handaxe #1723 and #1428, found below cluster C3[1], are larger tools, though do not share many similarities

(Figure 8.26). Handaxe #1428 appears to have been more intensively worked, at least on one side, though the flint used appears to be poor quality, which had resulted in multiple step fractures. It also appears fresh, whereas #1723 is rolled and abraded.

The Pit C assemblage

The assemblage of artefacts from Pit C was selected for a separate analysis due to the more complete contextual data available, which allows the tools to be differentiated on the basis of geology (whether they were recovered from the Palaeolithic Floor or Contorted Drift). Therefore, this data, as well as typological data based on Roe's methodology, was used in the interpretation of the results from the Pit C assemblage.

Analysis of the surface data

Principal component analysis applied to the handaxe surface data extracted only one component with an eigenvalue greater than 1.0. This component is heavily weighted for all of the variables under study and explains 90.45% of the variance within the Pit C sample (Table 8.10). In order to explore the results further, a second component was extracted, though this accounts for only 1.97% of the total variance. This second component is weighted for variables associated with horizontal and right horizontal orientations.

Scatter diagrams of the results were produced using typological and contextual data to differentiate the handaxes. Figure 8.27 clearly shows that there is no separation of tools based on their outline shape, though it is notable that pointed forms are generally found near the centre of the diagram, while the ovates appear more variable. When the contextual data is applied, there is very little separation of the handaxes according to whether they came from the Palaeolithic Floor or Contorted Drift (Figure 8.28). Clustering of 'genetically' associated surfaces is not prevalent, which suggests that in most cases the thinning technique was altered to accommodate differences between the two sides of a tool. This is exemplified in #1729, which provides an extreme case where the two surfaces are greatly disassociated. Examination of this handaxe shows that flakes removed from one side tend to follow a pattern radiating across the face from the tip, while the other surface indicates flakes removed from the edge (Figure 8.29). This has resulted in the presence of higher numbers of horizontal lines within the scar pattern trace for one side, leading to this surface being represented as an extreme outlier to the rest. However, some surfaces associated to the same tool do cluster. It is interesting to note that this primarily occurs with handaxes from the Palaeolithic Floor, and most noticeably with those tools suggested to be the product of the same knapper (Bradley & Sampson 1978: 94, see Figure 8.30). It is unlikely that movement of the Contorted Drift artefacts is responsible for the fact that the handaxe surfaces from this context do not cluster, given that the tools do not exhibit exceptional post depositional damage beyond abrasion. In addition, several tools only display scratching on one side (see Figure 8.31), which suggests that deposition of the Contorted Drift artefacts into the solution hollow at Pit C was likely to have been a slow process, involving a period of surface exposure followed by movement across a gravel surface on one side (Mark White, pers. comm.). Therefore, the grouping of handaxe surfaces may indicate subtle differences in the thinning and finishing techniques used by hominins contributing to the Palaeolithic Floor and Contorted Drift.

Though the diagrams show that there is no apparent clustering related to the shape or context of the artefacts, several groups can be identified. These groups correlate well with what is seen in the analysis of the combined Caddington assemblage. The first cluster (C1) contains two tools, both of which have been made on small tabular blanks, display a low intensity of flaking and small amounts of cortical retention. Cluster C2 contains surfaces from seven tools, all of which are also small and created using smaller flint blanks or, in the case of the handaxes from the Contorted Drift, pebbles. It is relatively similar to C1, though the intensity of flaking could be considered slightly higher. All of the tools generally display a low intensity of flaking.

The third cluster (C3) contains the surfaces from seven tools, though only three handaxes have both surfaces contained within this group. The majority of the handaxes show a higher degree of flaking and are slightly larger in size, though the surface from #1732 is cruder and shows a very low degree of flaking. However, it must be noted that the other surface from this tool is greatly disassociated and its position may move relative to this when the combined data is analysed. As a result, it cannot be firmly identified as part of this cluster. In addition, most of the artefacts originate from the Contorted Drift, though #1647 may actually be from the Palaeolithic Floor, given Bradley and Sampson's (1978: 130-6) assessment of the white corticated artefacts and Smith's (n.d.) note that this handaxe was "thrown out of a hole".

Cluster C4 contains surfaces from a total of ten handaxes. Eight of these have both surfaces within the group. All of these tools are much larger in size and generally display more intensive flaking across their faces. Only three handaxes are associated to the Palaeolithic Floor and appear to have been created using tabular nodules. The tools from the Contorted Drift indicate the use of a combination of sub-spherical and thicker tabular nodules, with both cruder and more refined forms present.

The final cluster (C5) contains eight handaxes, two of which are represented by a single surface. The cluster contains two implements from the Palaeolithic Floor, though one of these has only one surface within the group and displays a lower intensity of flaking. The other is an intensively thinned and acutely pointed form described by Smith as "of the highest possible finish" (1904b: 157). However, though this tool is assigned to the Palaeolithic Floor according to the British Museum records, Smith's account notes that this tool was originally recovered from the Contorted Drift deposits. The remaining tools from the Contorted Drift are generally thicker tools that show moderately intensive flaking and most appear to have been made using sub-spherical flint nodules.

The examination of the individual clusters indicates that differences in the scar patterns appears to be dependant on the size of the artefacts, which in turn is dictated by the nature of the raw material acquired for reduction. It appears that where the nodule selected for use is larger, more intensive thinning is common. On the other hand, smaller artefacts show a more conservative approach to thinning, which is suggested to be indicative of a degree of care taken so as not to over thin, break or miniaturise handaxes during manufacture. There also appears to be a subtle difference in the raw materials used within the Palaeolithic Floor and Contorted Drift assemblages. The former appears to consist of generally small, tabular blanks, while the latter sees a prevalence of thicker nodules, with more sub-spherical flint raw material being utilised. Whether this represents a change in the raw material availability between the Palaeolithic Floor and Contorted Drift assemblages is open for debate. However, the results clearly show that hominins at Pit C modified their reduction strategies in response to the quality of the raw material they used.

Analysis of the combined data

Principal component analysis applied to the combined data from the Pit C assemblage extracted only a single component with an eigenvalue greater than 1.0, accounting for 94.26% of the total variance within the sample (Table 8.11). In addition, the presence of negative eigenvalues indicates that the results should be treated with caution. This is suggested to be the result of the low number of cases being investigated compared to the high number of variables. Unfortunately, this is an aspect of the archaeological record that cannot be circumvented. To aid the interpretation of these results, a second component was extracted, though this explains a much lower amount of the variance seen. The two components can be correlated to the variables as follows:

- Component one displays heavy weighting for all the variables under study.
- Component two is explained by variables associated with horizontal orientations, particularly in the right horizontal.

Scatter diagrams of the results were produced using both typological and contextual data to differentiate the handaxes (Figures 8.32 and 8.33). These diagrams are generally in agreement with those produced from the analysis of the surface data. Therefore, despite the potential issue with the principal component analysis, the results are considered viable for further examination.

The results were broken down into a series of three groups. Despite the reduction in the number of groups, these conform relatively closely to those seen in the results from the analysis of the surface data. This is likely due to the combination of the data in order to represent the scar patterning across each handaxe as a whole. The first of these groups (C1) contains five handaxes, only one of which is associated to the Contorted Drift. All of the tools from the Palaeolithic Floor are small and display some cortex retention. These tools were primarily made using small tabular blanks. Three of these tools belong to the group suggested to be the product of a single knapper (Bradley & Sampson 1978: 94). The handaxe from the Contorted Drift is also small in size, but is thicker and was probably made using a small sub-spherical nodule or flint pebble. All of these cases display a low intensity of thinning, with the aim being to produce a usable tool without breakage or extensive reduction.

Cluster C2 contains seven handaxes. Only two are from the Palaeolithic Floor. One of these tools displays a high degree of cortex retention, while the other has very little residual cortex. Both appear to display larger thinning flake scars used to reduce and shape them, with more intensive flaking around the tip. A third handaxe (#1647) may accompany these tools, as it may be attributed to the Palaeolithic Floor (see above). The artefacts from the Contorted Drift are generally thicker in profile and are scratched or abraded. Most of these tools appear to be made using sub-spherical nodules, as opposed to tabular blanks, although one may have been created using a naturally occurring flake or 'pot lid'.

The final group (C3) contains nine artefacts. Again, only two of these can be associated to the Palaeolithic Floor. These handaxes are larger with a higher degree of thinning and were probably made upon large tabular flint nodules. The remaining tools from the Contorted Drift are also larger in size and generally more intensively thinned, though some show a lower degree of thinning on one side. The majority of these handaxes are thicker in profile and in most cases were made using sub-spherical nodules.

The remainder of the handaxes form a number of outlying points. Handaxe #1416 and #1468 correspond to cluster C1 from the surface analysis. Handaxe #1729 is an extreme outlier, which may be attributed to the greater degree of horizontal lines appearing in its scar pattern trace. Handaxe #1661 also does not cluster closely with the other tools. This tool is much thicker in profile, with limited flaking across both surfaces, and was almost certainly produced from a sub-spherical flint pebble. Handaxe #1723 and #1428, found below C3, represent two larger tools. Both show a higher degree of flaking on one side compared to the other. However, #1428 is thinner in profile and appears to have been made from a large tabular nodule, while #1723 is abraded and thicker. Handaxe #1688, the refined and intensively worked point described by Smith (1904b), now stands slightly apart. It is thin in profile, with small amounts of cortex on both surfaces, suggesting that it was made using a flat or tabular nodule. Finally, #1705 and #1706 are found slightly above the second group. Both tools are from the Contorted Drift, are much thicker in profile and display cortex retention on one surface. They appear much cruder in form, with large removals used to shape them. Both handaxes were likely created from larger nodules.

Again, the results suggest that differences in the scar patterns on the handaxes from Pit C correlate to the size of the nodules selected for reduction. In addition, closer examination of the tools shows that there is a difference in the types of raw material used to produce the Palaeolithic Floor and Contorted Drift assemblages. However, this difference in raw material does not especially impede the reduction strategy used and the scatter diagrams indicate that there is no real difference between tools from the two contexts studied, regardless of whether they were produced using one flint type or the other.

Summary

The results from the analysis of both the combined Caddington assemblage and the artefacts specifically associated to Pit C provide a highly interesting departure from the replica and Boxgrove assemblages. Overall, the variance within the samples is less complex, as explained by the lower number of extracted components. However, examination of the scatter diagrams indicates that a suite of factors has influenced the formation of the scar patterns on the Caddington handaxes. There appears to be a degree of separation amongst the tools that is dictated, in part, by the selection of raw materials, especially in terms of nodule size, with clusters showing the use of smaller tabular blanks and pebbles, larger tabular flint and flat nodules, and sub-spherical nodules. This variation in raw material acquisition will almost certainly have affected the reduction strategy applied (Ashton & McNabb 1994; Pettitt & White 2012; White 1995, 1998a). However, other factors include; differences in the types of nodules selected, differences in knapping skill, variation in the knapping strategy applied, and contrasts between tools from the Palaeolithic Floor and Contorted Drift.

The most intriguing of these is the fact that handaxes appear to cluster according to the brickearth pit they were recovered from, with artefacts from Pit E and F appearing separated from Pit A, C and G. Significant differences in raw material do not seem to be the cause of this separation. Therefore, it is possible that there is a subtle distinction in the way handaxe manufacture was conducted at Pit E and F. While not explicitly advocated here, due to a lack of any additional supporting evidence, this may be taken as representative of differences in a shared group template for the manufacture of handaxes (Pettitt & White 2012; White in press). It also suggests that the brickearth pits are not contemporaneous, as Smith (1894) originally suggested. This has already been expounded by Sampson (1978b), who noted that the horizons containing artefacts formed in isolated solution hollows within the chalk. However, the difficulties of suggesting an explanation for the variation seen is compounded by the fact that the assemblage contains tools from Smith's Palaeolithic Floor and Contorted Drift, the latter of which are almost definitely derived artefacts from an unknown number of sources (Bradley & Sampson 1978). Unfortunately, at this time the data require to separate the tools based on their context was unavailable and or can be considered spurious. Many of the entries in Smith's (n.d.) List of Palaeolithic Implements note that artefacts were moved by workers during the removal of the brickearth. However, regardless of whether of all of the tools within Pit E and F are contemporary or not, the fact that they differ from those seen at the other pits suggests that hominins were manufacturing handaxes in a subtly different manner. Whether this is due to differences in a group template for the production of tools, or down to the fact that the assemblages were not deposited at the same time requires further investigation. As a result, it appears that a complex combination of differences in the knapping strategies applied at these sites, selection and availability of raw material, context and potentially knapping skill may explain the variation present within the sample. ***What can be firmly concluded, though, is that the artefacts from Caddington can no longer be treated as a single assemblage and further analysis is required in order to investigate them in more detail.***

While sound contextual data is lacking for the majority of the brickearth pits, the handaxes from Pit C were differentiated on the basis of their context as recorded in the British Museum catalogue. The results showed that, within this pit, there is no apparent difference in the scar patterns present on tools from the Palaeolithic Floor and Contorted Drift. However, closer examination suggests that there is a difference in the types of flint nodules being exploited. This may be due to the fact that artefacts from the Contorted Drift are likely to be older and deposited into the solution hollow at Pit C from an unknown number of locations and distances by solifluction or other natural methods (Bradley & Sampson 1978). However, it does appear that there are divergent patterns of raw material acquisition between the two contexts represented at Pit C. Such an interpretation must be treated with caution, though, as contextual information for all of the handaxes from Pit C cannot be considered sound. Several tools may have been associated with the wrong context in the British Museum catalogue (such as #1688 and #1647), while others do not have accurate contextual information due to the manner in which they were found (Smith n.d.). Therefore, it is recommended that this information be reviewed when conducting future analysis of the Pit C assemblage.

Within the results of the analysis of the surface data from both Pit C and the combined Caddington assemblage, little clustering of surfaces from the same tool was seen. This is comparable to the results from Boxgrove and indicates that knappers did not necessarily apply the exact same thinning strategy to both sides of the tool they were manufacturing. As has already been mentioned, this has serious implications for the study of individual knappers, for if two sides of the same tool cannot be tied to the same knapper then there is less hope for correlating multiple tools to the actions of a single individual. It appears that hominins changed their thinning strategies in order to accommodate differences in the raw material, or to address flaws and mistakes. This certainly speaks of a highly adaptable approach to the reduction of flint that could be modified not only between different tools, but also throughout the manufacture of a single handaxe.

Due to the failure of the methodology to trace knappers within the replica assemblage, none of the results can be attributed to differences based on the actions of individual hominins. However, it is interesting to note that handaxes that have been suggested to be the products of one individual cluster together. This is especially evident with the series of handaxes from Pit C that were suggested to be the work of a single individual based on their morphology and the raw materials used (Bradley & Sampson 1978). Although they do not group together tightly, two clusters formed during in the analysis of the Pit C assemblage that contained these handaxes. While it cannot be explicitly stated that these are the work of a single hominin, it emphasises that the approach taken towards the thinning of these tools must have been very similar in order to produce comparable scar patterns. Again, this could be used to argue for the presence of a common reduction strategy, though it should also be noted that these tools were all produced from similar flint blanks, which may have influenced the knappers' approach (White 1995, 1998a).

Overall the handaxes from Caddington indicate differences in scar patterning that result directly from the size of the raw material chosen for exploitation. At the same time the contrast in scar patterning at Pit E and F is taken to be the result of subtle differences in the thinning strategies used by the hominins at these sites. In addition, differentiation of the tools according to the brickearth pits from which they were recovered strongly suggests that artefacts found in and around Caddington can no longer be treated as a single assemblage. Instead each pit must be viewed as an individual site that cannot definitely be considered contemporaneous with the others. Further work is required to investigate these sites individually and reaffirm their place within the context of the British Lower Palaeolithic.

FOXHALL ROAD

All fifty-eight handaxes selected for study from Miss Layard's investigations at Foxhall Road were analysed. The assemblage was combined to investigate whether there are any differences between artefacts from the various stratigraphic layers at the site. The grey clay and red gravel assemblages were also analysed separately to explore the potential for knapping idiosyncrasies within the scar patterns on a more fine-grained scale. In all cases the artefacts were studied using data from both the handaxe surfaces, as well as combined data that represents each tool as a whole.

Analysis of the combined Foxhall Road assemblage

Analysis of the surface data

Principal component analysis extracted only a single component with an eigenvalue greater than 1.0 from the handaxe surface data. This component accounts for 92.14% of the total variance and is heavily weighted for all the variables under study (Table 8.12). This component appears to equate to the overall intensity of reduction applied to each handaxe. A second component was also extracted in order for the results to be investigated further. This component only explains 1.92% of the variance and is weighted for variables associated with horizontal orientations within the scar patterns, including right horizontal orientations.

The results of the principal component analysis were plotted as a series of scatter diagrams, using Roe's typology and the context of each handaxe to differentiate the tools. As Figure 8.34 shows, there appears to be little separation of the tools according to the context from which they were recovered, although it is notable that handaxes from the red gravels are predominantly found on the left side of the scatter. The same is true for the grey clay, though more tools from this assemblage can be seen on the right side of the scatter when compared to the red gravels. Figure 8.35, on the other hand indicates the separation of the handaxes into pointed tools toward the bottom of the scatter and ovates ranging across the middle. While there is a degree of overlap between the two types, this distinction is abundantly clear and follows a similar pattern to the division seen in the results from the replica assemblage. It appears that pointed tools within from Foxhall Road display a higher degree of vertically orientated lines within their scar pattern traces compared to ovate tools. This is interpreted as a result of the knapping strategy applied in the production of pointed handaxes, which do not show the same degree of centripetal thinning as ovate tools (see Figure 8.8). Knappers must thin the tool along the edge, invariably resulting in the truncation of flake scars, which causes lines to extend from the tip and down towards the centre of the nodule. Ovates, on the other hand, are commonly thinned using generally more intensive circumferential working (Ashton & White 2003), resulting in a greater diversity of line orientation within the scar pattern, as well as generally higher numbers of flake scars.

The scatter diagrams also show that clustering of 'genetically' associated surfaces is not prevalent. This is in agreement with the findings from the other archaeological assemblages studied and reemphasises that knappers do not thin both sides of a handaxe using the exact same reduction strategy. Rather, they appear to alter their approach in response to both the raw material and the degree of thinning that has already been applied. As has already been mentioned, this adds a new level of difficulty when attempting to trace the actions of individuals within the archaeological record, due to the fact that a knapper's actions change fluidly during the manufacture of a single tool.

An attempt was made to divide the handaxes into groups using the patterns displayed within the scatter diagrams. While no well-defined clusters can be observed, there does appear to be a split between handaxes found on the left of the scatter and those found on the right. This was investigated further, although the fact that related surfaces from several handaxes are found to spread throughout both clusters means that these groups are not considered distinct. Examination of the combined data produced more defined clusters and these are discussed in the next section.

Analysis of the combined data

Principal component analysis applied to the combined data also extracted a single component with an eigenvalue greater than 1.0. This accounts for 95.35% of the total variance (Table 8.13). This component is heavily weighted for all of the variables under study. Again, this appears to relate to the intensity of reduction used during the final thinning stages. In order to analyse the results using scatter diagrams, a second component was extracted. This explains a much lower amount of the variance (1.35%) and is weighted for variables associated with vertical orientations, which is opposite to what is seen in the surface analysis.

Scatter diagrams of the results were created, using both typological and contextual data to differentiate between the handaxes. These diagrams are similar to those produced for the analysis of the surface data, though they appear inverted due to the different weightings of the second component. However, no major differences in the positions of the handaxes relative to component one are noted. Figure 8.36 continues to show that there is limited separation of the handaxes according to the stratum from which they were recovered. However, fewer tools from the red gravel assemblage can be found on the right side of the scatter when compared to the grey clay. It is also noted that the grey clay assemblage appears to cluster together tighter than the red gravel, suggesting that there is more variability in the latter. However, there is a great degree of spread within both of these assemblages and differences between the two are subtle at best.

Figure 8.37 shows the continuation of the division between pointed and ovate forms. Due to the inversion of the scatter diagram, pointed forms now group toward the top of the scatter, while ovate forms range around the bottom. Again, this appears to emulate the division according to shape seen in the replica assemblage and contrasts with the results from both Boxgrove and Caddington. However, it should be noted that the Foxhall Road assemblage contains a higher frequency of classically pointed forms compared to the other archaeological assemblages studied. In addition, many of the handaxes classed as pointed forms from both Boxgrove and Caddington are cordiforms and may have been misclassified using Roe's metrical typology. This may explain why a clear differentiation between pointed and ovate handaxes is not seen within the results from these sites.

The scatter diagrams were examined further in order to identify any potential clustering between the handaxes. A number of groups and outliers were identified. The first group (C1) contains twenty handaxes, all of which are smaller ovate or pointed forms. Roughly equal numbers belong to the red gravel and grey clay assemblages, with several others recovered during Miss Layard's 1902 investigations that have no fixed provenance. One other handaxe can be associated to the red and grey clay, which is much cruder and could be considered as an outlier to this cluster. The group as a whole presents a mixture of well-worked tools with some cruder forms, though all display a relatively low intensity of flaking used to thin them. The majority of the pointed forms can be attributed to the red gravel assemblage, with one other point coming from the 1902 investigations. It should also be noted that the cruder forms do not cluster as closely to the rest of the group, whereas handaxes that show a higher degree of skilful manufacture cluster much more tightly.

Cluster C2 contains seven handaxes. The majority of these are pointed forms, with a single ovate from the grey clay also included. The pointed tools mainly originate from the red gravels, although examples from the grey clay and the 1902 investigations are also seen. All of the tools show a low intensity of flaking and the pointed forms, especially those from the red gravel assemblage, are considered much cruder.

The final cluster of tools (C3) is found on the right side of the scatter. A total of sixteen handaxes are included in this group. The majority of these come from the 1902 investigations and unfortunately have no fixed provenance. However, four tools can be assigned to the grey clay, with a further three originating from the upper sand and gravel, gravelly clay and topsoil. An equal number of pointed and ovate forms are present. Of the ovate tools, five have twisted profiles, including all the examples from the grey clay. The handaxes are generally larger than those seen in the other groups found on the left of the scatter and display intensive thinning of both sides. Very few show cortex retention, and where present it is minimal. Most of the tools appear to have been made using larger flint nodules that would have allowed the knapping sequence to progress relatively unimpeded (Ashton & McNabb 1994; White 1998a). This is true for both the pointed and ovate implements. It can be said, with relative certainty, that the hominins involved in the production of these tools were capable and highly skilled knappers.

In addition to the larger clusters discussed above, there are a number of smaller outliers groups. Handaxe #38, #65, #127, #135, #137 and #158b are all found between the clusters on the left and right sides of the scatter. All of these tools are smaller than those seen in cluster C3, but display a much higher degree of intensive flaking than tools from C1 and C2. The majority of these handaxes are very finely worked and present evidence of highly skilled manufacture. Therefore, these appear to represent tools that grade between the smaller less intensively worked tools and those that are larger and display higher degrees of thinning. The group of three handaxes found below cluster C3, which includes #106b, #132b and #157b, are all larger, intensively thinned tools. Handaxes #106b and #157b are notable, as both are elongated and display almost identically worked tips. Although these are associated with the red gravel (#106b and #157b) and white sandy gravel (#132b), all three tools may in fact be derived from the grey clay (White & Plunkett 2004: 119). However, it is interesting that these tools do not cluster well with the other finely worked tools seen within C3. Finally, a series of pointed handaxes situated near the top of the scatter also form outliers. Three of these tools cluster together, two of which are from the grey clay, while the remainder originates from the red gravel. All three tools display cortical butts and limited working around the tip. They also show similar patterns of flaking and are very similar in profile. It is probable that they were all produced using small flint pebbles. However, due to the fact that they are sourced from different stratigraphic layers and are therefore almost definitely from temporally different periods of activity (see Chapter Four), it cannot be argued that they were the product of one individual. This may potentially be important, as it reflects the fact that temporally divided hominins may produce almost identical tools using very similar knapping strategies. Given the general recurrence of morphological forms during the Acheulean, as described in Chapter Two, this may not be surprising. However, it may be interesting to consider this from the perspective of transmission of learned behaviour, though the temporal divide present pre-empts any attempts to accurately discuss this in detail at the present moment in time. The remaining three pointed tools include #55b, a cruder tool that was worked along only one edge and produced from a small flint pebble. The second of these outliers is Handaxe #178, a larger pointed form with a much higher degree of thinning. The high degree of vertical lines in its scar pattern appear to originate from a tendency to remove flakes from the tip and butt across the centre of the tool, something that is especially prevalent on one side. The final outlier remaining to be discussed is #143, which is an extremely acute pointed form with a cortical butt and relatively low intensity of flaking. Again, its scar pattern displays high quantities of vertically orientated lines, which are suggested to have been caused by the overall shape of this tool affecting the way in which flakes had to be removed.

The results from the analysis of the combined data from the Foxhall Road assemblages correlates well to what is seen in the analysis of the surface data. Once again, there appears to be a split between the left and right halves of the scatter, with the former containing smaller implements with lower degrees of flaking, while the latter contains much larger tools that are more intensively worked. There are several tools that grade between these, generally representing smaller but well-worked tools. Extreme outliers to the main clusters tend to be cruder pointed artefacts or tools that show very different scar patterns in comparison to the rest of the assemblage. The two main assemblages from Foxhall Road, namely those from the red gravel and grey clay, show limited differences and appear relatively similar. It is only when the handaxes are examined in detail that the differences in the quality of the raw material used by the hominins, as suggested by White and Plunkett (2004), can be clearly demonstrated. This suggests that nodule size may have had a more restrictive role in determining scar patterning on the tools, rather than raw material quality. However, it should be noted that tools that are considered to display a higher degree of skilful working are found in cluster C1, while much cruder tools are generally found in C2 and amongst the outliers. Therefore, the fact that raw material quality had an effect on scar patterning cannot be ruled out and appears to be confirmed to some extent.

The results are also interesting in terms of an analysis of the actions of individual hominins. Several handaxes from the Foxhall Road assemblage have been suggested to represent the actions of individuals (Layard 1904; White & Plunkett 2004). Two of these include handaxes #42 and #48, both of which can be seen in cluster C3 and cluster together quite well. However, other tools, such as #61 and #62, which were found lying point to point (White & Plunkett 2004: 118), do not cluster together. It is also interesting to note that handaxes from different layers will cluster together, suggesting that thinning strategies did not alter greatly through time. Due to the difficulties in assessing the exact temporal difference between these layers it is difficult to assess whether tools are the work of single individuals. However, if we accept that the assemblages deposited at Foxhall Road were likely to be result of different events through an extended period of time, probably involving different groups of hominins, then tools resembling the actions of a single hominin may simply be linked to a common approach to the reduction of raw material. This has important implications for our current understandings of learning and the transmission of social behaviours between Lower Palaoelithic hominins. It has already been noted in Chapter Two that there are several possible methods of social transmission, with some considered to be more applicable than others (see Lycett & Gowlett 2008). If highly similar forms do appear within temporally spaced deposits, then this may speak of extended socially transmitted methods of tool manufacture being present. However, it is also possible that such evidence may be linked to a mode of production designed to achieve the desired tool function within a relatively limited range of options. In this case the level of input from any socially defined method of knapping is also influence by the desire to produce a functional object (though this may also be socially motivated) and the limits placed on the individual by the materials available. Further work is obviously needed to explore this in further detail and link such evidence to concepts of patterning within the Acheulean. As a result, however, it cannot be accurately determined at this point in time whether tools such as #42 and

#48, are the product of a single individual or the result of a standard knapping approach that was repeated through time.

Analysis of the Grey Clay assemblage

Analysis of the surface data

Principal component analysis applied to the surface data from the grey clay assemblage extracted a single component with an eigenvalue greater than 1.0. This component accounts for 94.41% of the variance within the sample and is heavily weighted for all the variables being studied (Table 8.14). In order to analyse the results using scatter diagrams, a second component was also extracted. This accounts for a much smaller amount of the variance and is weighted most strongly for variables associated to horizontal orientations. In addition, the principal component analysis resulted in the presence of several components with negative eigenvalues. This is due to the low number of cases compared to the high number of variables. As a result, the following interpretations can only be tentative. However, in general it is noted that the position of handaxes within the scatter diagrams discussed below is comparable to what has been seen in the analysis of the entire Foxhall Road assemblage.

Scatter diagrams produced from the results of the principal component analysis were created and typological data was used to divide the handaxes according to their outline shape (Figure 8.38). It is clear that there is a separation between ovate and pointed forms within the scatter and tools that fall on the left and right sides of the diagram. Clustering of surfaces associates to the same handaxe is not prevalent and many are widely dispersed, emphasising that there are clear differences in the way that each side of a tool has been thinned.

The division between points and ovate handaxes was explored further. The majority of the pointed tools show a lower degree of flaking and often retain large quantities of cortex. Many appear to be manufactured from small, oddly shaped flint pebbles. The only pointed handaxe that does not conform to this is #64, which is a larger and more intensively worked tool that lies on the right side of the scatter (Figure 8.39). The raw material used for the manufacture of this handaxe was of poor quality, yet the knapper appears to have been able to use an effective knapping strategy that involved minimal working to the butt and a more intensive reduction of the tip (White & Plunkett 2004: 110). It appears that, despite the poor quality, the size of the original nodule allowed a more flexible approach compared to the smaller pebbles. Finally, #65 is seen to group with the ovate tools. While clearly pointed, this tool appears to have been worked in a semi-circumferential fashion and displays a greater degree of flaking on one side (Figure 8.40). The knapper involved in its manufacture may originally have planned to produce an ovate tool from the flint pebble selected for manufacture, only to have the desired form go awry.

The ovate forms also show a differentiation based upon the flaking intensity applied during thinning, dividing the tools into those on the left and right of the scatter. Handaxes on the left are predominantly small and less intensively thinned, often appearing to be produced from flakes and, in some cases, small flint nodules that did not impede the knapping strategy. Those on the right are larger and much more intensively reduced, with all examples displaying a twisted profile. They exhibit little to no residual cortex and must have been produced from much larger flint nodules. However, it cannot be argued that large blank size is a prerequisite for twisted handaxes, as the comparatively smaller handaxe #49 also displays this type of profile and was made using a much smaller nodule or possibly a flake.

The results are in agreement with what White and Plunkett (2004) have suggested, showing that where raw material is of poorer quality or not uniformly shaped hominins appear to produce pointed handaxes. On the other hand, where the flint is of good quality and does not inhibit the knapping strategy, ovate handaxes were produced. However, the results also indicate a division in the size of the tools, which suggests that larger flint blanks enable a more intensive reduction strategy to be applied when thinning and finishing handaxes. This is apparent for both larger ovate and pointed forms, with ovate handaxes displaying an overall increase in flaking intensity, while pointed forms show increased thinning only around the tip. Coupled with the fact that handaxes rarely display a similar pattern of flaking applied to both of their sides, this indicates that hominins had a remarkably fluid approach to the manufacture of these tools and were able to change their knapping strategies to accommodate both size and quality of raw material.

Analysis of the combined data

Principal component analysis was applied to the combined data from the grey clay assemblage and extracted a single component with an eigenvalue greater than 1.0 that explains 96.17% of the total variance (Table 8.15). This component appears to be heavily weighted for all of the variables under examination. In addition, a further component was extracted in order to produce a scatter diagram so that the results could be reviewed. This component accounts for a much lower percentage of the total variance and is weighted for variables associated to horizontal orientations. Again, the analysis produced a large number of components with eigenvalues that are close to zero, or have negative values, which is due to the low number of cases involved in the analysis.

A scatter diagram of the results was produced using typological data to differentiate between pointed and ovate handaxes (Figure 8.41). This diagram is in relatively close agreement with the results from the surface analysis. Handaxe #61 and #69 are clear outliers to the other tools under study, primarily due to the predominance of vertically orientated lines within their scar patterns, which appear to have been caused by flaking along the edge. These two handaxes are rather different in appearance, however, with #69 displaying a higher degree of cortex retention, especially on one side. Handaxe #37 and #62 appear to cluster closely, though one is ovate, while the other is pointed. The reason for this may be due to the scar patterning one side of #62 displaying more vertically orientated lines, while the other shows a higher degree of lines that are orientated horizontally. As a result, the combination of the data from these two sides has caused its placement within the scatter to be closer to the ovate tools. In all other respects, #37 and #62 are very different in both form and scar patterning.

Though it is not possible to identify knappers, given the failure of the method to detect individuals in the replica assemblage, it is interesting to note that some tools suggested to be the work of a single hominin do cluster together. Within the grey clay assemblage this encompasses #42 and #48 (Layard 1904; White & Plunkett 2004), which group together closely, though can also be associated with #69b. In addition, #35 and #36, suggested to be very similar by White and Plunkett (White & Plunkett 2004: 105), are also found close together, though associated with the slightly dissimilar ovate #172 and grouped closely with the other small ovate tools from this assemblage. The fact that these tools do cluster closely may be indicative of the actions of a single individual. However, the fact that they are not significantly removed from the other tools within the assemblage suggests that, though similar, they are the results of a broadly similar knapping trajectory. As a result, the analysis does not confirm, nor deny, the possibility that these may represent the products of individuals. However, it stresses caution over the interpretation that these explicitly are evidence of a single hominin's actions.

Analysis of the Red Gravel assemblage

Analysis of the surface data

Principal component analysis applied to the surface data from the red gravel assemblage extracted a total of two components with eigenvalues greater than 1.0 (Table 8.16). These account for 94.50% of the total variance within the sample. Again, component one was weighted for all the variables under study, while component two is weighted for those variables associated to horizontal orientations. Again, the analysis also resulted in the presence of several components with negative eigenvalues and is suggested to be due to the low number of cases under study. As a result, caution should be taken over the interpretation of these results.

A scatter diagram of the results was produced using typological information to differentiate between pointed and ovate forms (Figure 8.42). It is clear that, while there is no defined separation between these two types, pointed forms display a much greater degree of variation. This variation is mainly in the values for component two, reflecting differences in the amount of horizontally and vertically orientated line in their scar pattern traces. On the other hand, variation amongst the ovate tool appears to reflect differences in the values for component one. As handaxes on the right of the scatter appear to show higher flaking intensities, while those on the left have much lower amounts of flaking, component one appears to reflect differences in the amount of thinning applied to each tool. The fact that ovate tools do not show a high degree of variation in component two is suggested to be due to the fact that these tools are centripetally worked, resulting in a greater diversity of line orientation within the scar pattern trace. However, flakes extending across the surface from the edge generally cause a slight increase in the number of horizontally orientated lines. Pointed handaxes, on the other hand, are generally worked only along the edge and generally around the tip. Flaking usually extends either across the face of the tool from the edge, or down from the tip. In addition, flaking from the edge is often truncated by further removals. This appears to result in a preponderance of vertically orientated lines within the scar pattern traces of these tools.

Clustering of 'genetically' associated surfaces is not prevalent in the red gravel assemblage, which continues the pattern seen within the result from the other archaeological assemblages. In some instances, the pattern of flaking varies dramatically between the two surfaces of the same tool. A prime example is #48b, where one surface shows predominately horizontal lines within the scar pattern, while the opposite shows a higher degree of vertical lines.

As noted above, there is an increase in the flaking intensity applied to the tools from the red gravel as the value of component one increases. This has led to a slight split between the majority of the assemblage and two outlying tools. These handaxes are #106b and #157b, both of which are elongated ovate forms and display tranchet removals across the tip. They are remarkably similar in form and execution, displaying a much higher intensity of flaking compared to the other handaxes within this assemblage. As has already been noted, however, these tools may have been derived from the grey clay assemblage (White & Plunkett 2004: 119).

The remaining ovate handaxes from the red gravel assemblage are relatively well worked, though all display a much lower intensity of flaking. In addition, they are all of much smaller size. Only #50b stands out as being markedly different. This handaxe displays a very low intensity of flaking, with larger removals used to thin and shape it. It was most likely produced from a flint pebble or a thick flake removed from a small nodule.

The pointed tools display a range of cruder forms, with the notable exception of #168, which is intensively worked, despite its small size. The crudest forms tend to be those that have the lower values in component two, generally representing those tools that have cortical butts and flaking only about the tip. Handaxes that are found nearer to the ovate forms display flaking over more of the surface area, though in most cases the butt still retains some cortex.

Again, the results are in agreement with what White and Plunkett (2004) have shown, with the majority of the handaxes representing cruder pointed forms, generally produced on poorer quality flint pebbles, while the few ovate tools are made from material that affords a centripetal mode of reduction. There is a noticeable reduction in larger handaxes, suggesting that larger raw material was not exploited as much when compared to the grey clay assemblage. In addition, if #106b and #157b are associated to the grey clay, then this would reduce the number of larger tools to zero, meaning that hominins involved in the deposition of the red gravel assemblage were limited to much smaller pieces of flint that were of lower quality. It is also agreed, given the results of the scar pattern analysis, that raw material form and quality has affected the thinning strategy applied to the tools, with pointed forms showing much higher incidences of vertically orientated lines within their scar pattern traces. This is suggested to be the result of flaking being primarily restricted to the production of the tip during the manufacture of these pointed forms. In comparison, ovate handaxes see the use of a centripetal reduction strategy, resulting in a greater diversity of line orientations within their scar pattern traces.

Analysis of the combined data

Principal component analysis was also used to explore the combined data from the red gravel assemblage. The analysis extracted a single component with an eigenvalue greater than 1.0, which explains 95.70% of the variance within the sample (Table 8.17). This component is heavily weighted for all of the variables under study. In order to produce scatter diagrams for the results to be visualised, a second component was also extracted. Again, this component explains a much lower amount of the variance and is weighted for variables associated with vertical and left central orientations. This is in contrast to the second component extracted in the analysis of the surface data. In addition, the presence of negative eigenvalues means that the interpretation of the results can only be viewed as tentative and a degree of caution is advised.

A scatter diagram of the results was produced using typological data to separate the handaxes in to pointed and ovate forms (Figure 8.43). The scatter appears inverted when compared to that produced from the surface data analysis, due to the difference in component two. However, when this is taken into consideration, the overall position of the handaxes has changed little. There is still a clear division between pointed and ovate forms, with pointed handaxes displaying higher incidences of vertically orientated lines within their scar pattern traces. Two clusters of tools can now be seen, and are discussed below.

All four of the handaxes contained within cluster C1 are cruder pointed forms that display minimal working. In most cases relatively few flakes have been removed in the attempt to establish a working edge and tip. A second cluster of mainly pointed handaxes (C2) is found below this group. This group contains handaxes that are relatively crude, though there are some examples of well-worked tools. Handaxe #72, #76 and #77 are cruder with cortical butts, though they display an increase in flaking over their surface area compared to the tools seen in cluster C1. Handaxe #168, on the other hand, is more intensively thinned and displays very little cortex retention. It is grouped with #78b, a small well worked ovate. This may be due to the fact that #78b shows an increased number of vertically orientated lines on one side, mainly caused by a large removal extending from the tip. Therefore, combination of the data has resulted in its current position amongst these pointed tools. The remaining handaxe, #170, also clusters with #78b and #168. This is a thicker and arguably cruder form. However, it displays an increase in flaking when compared to the other cruder handaxes within this cluster C2, which is suggested to be the reason for its current position within the scatter.

The remaining tools form a series of outliers. Handaxe #55b is the most extreme, displaying high values in component two. This is interpreted to be the result of flaking applied to the tip of this handaxe, which has created a single cutting edge and resulted in a predominance of lines that are orientated either vertically or within the left central zone. The ovate tools within the red gravel assemblage also mainly from isolated outliers. Handaxe #50b and #94b are considered to the closest associated ovates. Both are small and display a low intensity of flaking, though #50b is considered cruder and displays significant cortex rotation, as well as a lower scar count. The remaining ovate handaxes appear on the right side of the scatter, with #106b and #157b showing the highest values for component one. Both of these tools are much larger, more intensively flaked and display almost no cortex retention, and must have been produced from very large blanks. Again, both handaxes may be derived from the grey clay. Either way, it can be argued that hominins had little access to large, good quality flint nodules at the time the red gravel assemblage was deposited.

The analysis of individual knappers within the red gravel assemblage is not strictly possible, due to the failure of the current methodology to identify the knappers in the replica assemblage. However, the results from the red gravel do point to the fact that handaxes showing no clear similarities can display similar line orientation within their scar patterns traces. This is most clearly demonstrated by the clustering of handaxe #170 with #78b and #168. Here #170 is much cruder in form, while the other handaxes associated with it show a higher degree of flaking and appear relatively to have been skilfully worked. While the scar patterns are also not directly comparable, the overall pattern of line orientation is similar, which has caused these tools to be grouped together. While it cannot be definitively stated that these tools were not the product of a single individual, it seems unlikely, especially given the results from the replica assemblage. This emphasises the fact that tools created by different individual may produce highly similar results and indicates a further issue to be resolved in the attempt to trace individual knappers.

Summary

The results from the Foxhall Road assemblages appear to correlate well with the replica assemblage, showing a clear division between pointed and ovate handaxes that is not seen at Boxgrove or Caddington. It has already been suggested that this division is not present in these assemblages due to a lack of classically pointed forms, while Foxhall Road displays a greater variety of tools. However, the assemblages from Foxhall Road differ from the replica assemblage in that the division between pointed and ovate handaxes appears to be the result of gross differences in the quality of raw material. The pointed handaxes from Foxhall Road display larger amounts of cortex retention, with flaking primarily restricted to the tip. The replica assemblage, on the other hand, is made up of larger and more finely worked pointed forms, with flaking extending over much of the surface area of each handaxe. However, the fact that both assemblages indicate that pointed handaxes generally show a higher incidence of vertically orientated lines within their scar pattern traces indicates that the manufacture of this type of handaxe causes a significant change to the thinning and finishing stages of reduction when compared to ovate tools. This means that the orientation of lines within the scar patterns seen on ovate and pointed tools will generally be very different, even if these tools were produced by the same knapper and regardless of the qualities of the raw material being used. This has obvious and important implications when trying to trace individual knappers within an assemblage. One answer to this may be to break each assemblage down into pointed and ovate forms and analyse these types individually. However, such an approach would not allow pointed and ovate tools produced by the same knapper to be identified.

The Foxhall Road assemblages also show a division that is dependent upon the size and intensity of flaking seen within the scar patterns. Larger handaxes tend to show increase values in component one, reflecting an increase in the overall diversity of line orientations within their scar patterns, which results from the higher number of flakes removed in the thinning and finishing stages of manufacture. Smaller tools generally display lower values of component one, for the opposite reason. In most cases this appears to be a result of the size of the raw material acquired for reduction, though in some instances smaller ovate tools may have been produced on larger blanks compared to the small flint pebbles that were selected for the production of pointed handaxes. A similar division is seen in the results from the Caddington assemblages, though this separation is not as clear. This may be due to the fact that the raw materials available for reduction at Caddington are more homogeneous in terms of their overall quality, while at Foxhall Road there is a much larger disparity between very poor and higher quality flint. This division is also noted in the Boxgrove results, though to a much smaller degree, mainly due to the fact that the vast majority of the Boxgrove handaxes are of similar size and shape. However, those smaller handaxes that are present do tend to produce lower values for component one.

In terms of tracing hominins, the Foxhall Road assemblages have provided evidence that both supports and impedes the identification of actions tied to individuals. Handaxes that have been suggested to be the product of the same hand solely on the basis of shape and gut feeling often cluster together well within the scatter diagrams that have been produced. While this indicates that they display good correlations in terms of their scar patterning, it does not necessarily mean that they are definitely linked to the same knapper. The clustering of tools that are visually dissimilar, especially crude and refined tools, suggest that radically different handaxes may present relatively similar results when their scar pattern traces are analysed. While it cannot be denied that this may indicate the presence of the same individual's knapping strategy, it emphasises that caution must be taken when suggesting that two very similar tools may be the product of the same hominin. It is suggested that further work is required to fully understand how scar patterning develops and how highly similar scar patterns may emerge.

Overall, the results from Foxhall Road show that scar patterning on the handaxes studies appears to be influenced by the size of the nodule or blank selected for reduction, the size of the tool itself and the shape of tool being produced. Given that the difference between pointed and ovate handaxes from Foxhall Road appears to be based on differences in the quality of the flint used in the manufacture of these tools, it is highly likely that this has also affected the final scar patterns seen. In addition, while handaxes that are suggested to be linked to a common individual do cluster together, the presence of crude and well-worked handaxes within the same cluster suggests that there are more variables involved in the scar patination seen than the knapper alone. However, this is not to deny that, where handaxes are elaborately worked and unimpeded by the raw material, such as the larger ovate tools seen in both the red gravel and grey clay assemblages, an individual's imprint may rise above the other factors suggested to be responsible for the flake scar patterning that is seen.

DISCUSSION AND SUMMARY

This chapter has discussed the application of a methodology for analysing scar patterns to both replica and archaeological assemblages. This methodology is similar to that which Gunn (1975, 1977) proposed was able to directly link knappers to their creations. As has been noted previously, Gunn tested this methodology using a series of tools created by five modern knappers that were all based on a sixth archaeological sample. In constructing the replica assemblage he required all of the knappers to produce tools of a specific shape and size, as well as imposing a restriction over the raw material available. While Gunn's analysis was able to detect the individuals involved in his experiment to a certain degree, the analysis of the replica assemblage presented here was not able to differentiate handaxes according to the knapper who produced them. However, the assemblage used is very different to Gunn's, presenting a range of shapes, sizes and raw materials. Therefore, the analysis of the replica assemblage demonstrates that, although Gunn may have been able to isolate the actions of individuals within an assemblage that has had heavy restrictions imposed upon it, where there is a higher degree of variation in the handaxes, the individual remains hidden. Instead, the overall shape of the tool appears to have a larger affect on scar patterning than the individual knappers. However, it was notable that the handaxes associated to Knapper 1 did group together. As the majority of this knapper's tools were similar in form, this does suggest that where variations in shape are not a mitigating factor, the individual leaves an imprint within the scar patterns they create. Yet it must be highlighted that this knapper's implements did not form a distinct cluster relative to the other tools in the replica assemblage and that tools produced by other knappers were also found to group closely with them. This poses a significant issue in terms of tracing individual knappers through the final form of the tools they produce and emphasises that handaxes may show similar scar patterning, despite the fact that they were produced by two entirely different knappers.

The examination of 'genetically' associated surfaces from all of the assemblages has shown that two sides of the same tool are often dissimilar. Sometimes this can be to a great extent, with each side displaying evidence of highly divergent thinning techniques. These results are similar to those from the analysis of three-dimensional morphology, which also showed that surfaces from the same tool rarely clustered together. This has obvious implications for the study of the individual, but also emphasises that knappers employ a fluid approach to the manufacture, thinning and shaping of handaxes, modifying their techniques in order to achieve their desired results, rather than following a regimented pattern of reduction. Therefore, knappers made decisions in response to a variety of factors in order to obtain satisfactory end results that have clearly resulted in these divergent scar patterns appearing.

While analysis of the replica assemblage shows a distinct separation between pointed and ovate handaxes, the variation in the archaeological assemblages is much less complex, producing far fewer components when analysed, and appears to indicate differences based on the intensity of flaking applied to the handaxes. This appears to have been greatly influenced by the overall size of the tools, with larger handaxes displaying much more intensive reduction in comparison to smaller ones. This differentiation is not noticeable in the results from the replica assemblage. However, all of the handaxes in this assemblage are of roughly the same size, although a reappraisal of the results does show that #8, a much smaller ovate, is slightly separated from the rest of the sample (see Figure 8.5a). This suggests that the replica assemblage is not an appropriate parallel to what is seen in the archaeological record. If such an experiment were to be repeated in the future, it is strongly advised that any replica assemblage attempts to emulate the archaeological record as closely as possible.

The size of the artefacts, and the way this has influenced the pattern of flake scars upon the handaxes studied from the archaeological assemblages, appears to have been directly influenced by the raw materials available for reduction. At Caddington, size of the artefacts appears to be a reflection of the original size of the nodules available, the majority of which were smaller tabular and sub-spherical nodules. At Foxhall Road a similar pattern is seen, with most tools produced from smaller flint pebbles or flakes, while the larger pointed and ovate forms are manufactured using what must have been sizable flint nodules that both allowed for larger tools to be produced and did not impede the knapping strategy as much. However, White and Plunkett (2004) note that some of the smaller ovate handaxes from Foxhall Road may originally have been produced from sizable flakes, especially where little cortex retention exists on the finished tool. The effects of raw materials are not as clear at Boxgrove. This is suggested to be caused by the relatively homogeneity of the assemblage and the fact that hominins were selecting roughly similar materials in terms of both quality and size, favouring nodular flint over more difficult tabular forms (Roberts & Parfitt 1999). However, there are a low number of instances where handaxes have been produced from what appears to be smaller flakes or nodules. Where this occurs a similar reduction in flaking intensity is noticed and knappers begin to use a slightly more conservative thinning technique, designed to thin and shape the tool without reducing its utility.

In addition to issues of size of both artefacts and raw materials, the results have shown potential for the identification of knapping strategies that may be socially informed and based on a group template. This is most clearly seen with the separation of handaxes from Pit E and F from the other brickearth pits at Caddington. There is little difference in the flint used for manufacture at these pits, as well as no significant differences in the size of the tools. Therefore, these factors do not appear to have caused this differentiation. It has been noted that all of the pits studied have a combination of artefacts that were found *in situ* on the Palaeolithic Floor and others discovered in the

Contorted Drift, the latter of which have been derived from a unknown number of sources (Bradley & Sampson 1978: 139). This introduces an issue of separating the artefacts according to their associated context, which was achieved to a certain extent with the Pit C handaxes, but proved more difficult for the other tools. Sampson (1978b) has also stated that the Palaeolithic Floor is not a continuous feature, as Smith (1894) originally claimed, but is rather a number of separate features developing at the base of solution hollows formed in the chalk bedrock. Therefore, the contemporanity of not only each brickearth pit, but also the artefacts within them cannot be defined with accuracy. As a result, the differences seen at Pit E and F could be argued to result from temporal or cultural factors, or both. However, this does not deny that the hominins who were involved in the creation of handaxes at these pits were working flint in a subtly different way to hominins at Pit A, C and G. Of course the issues surrounding the Caddington assemblages that have been outlined in this chapter prevent an overall conclusion being drawn and it is suggested that further analysis of this suite of sites is needed in order to form a complete understanding of what is occurring here. However, it can be emphatically stated that the Caddington assemblage can no longer be treated as a whole.

The Boxgrove assemblage also suggests the presence of group-mediated knapping strategies, though in a different manner. The fact that the majority of handaxes produced by the hominins at Boxgrove cluster together indicates that there must be a high degree of overall similarity in the make up of the scar patterns seen within these assemblages. This then suggests that the thinning strategy used in the production of these handaxes was also relatively similar. It was also noted that cruder and more refined handaxes are found within the larger clusters produced from the Boxgrove data. This may also indicate that knappers of different levels of skill attempted to follow a similar learned technique that was designed to produce an idealised and functional shape. Overall, whether this represents a socially mediated method of reduction, or is simply a result of the production of handaxes from relatively similar raw material, is debateable. However, the results lend support to the notion of knapping strategies that are defined by the social group, as has been suggested for Caddington, although further analysis is needed to fully explore this proposition.

Finally, the results from the analysis of scar patterns from the archaeological assemblages did exhibit clustering of handaxes that have been suggested to be the work of the same individual. Such handaxes include #1416, #1417, #1418, #1419 and #1468 from Caddington, as well as #42 and #48 from Foxhall Road. Due to the fact that the methodology used was unable to accurately cluster the products of single individuals, it cannot be stated that these cases are unequivocally linked to the work of one hand. In addition, the fact that handaxes produced by different individuals often produced similar results emphasises this point of view. Yet, as the tools produced by Knapper 1 have shown, handaxes made by a single individual that share similar size, form and flaking could group together. Therefore, it is impossible to fully deny that these handaxes are the results of a single hominin's actions. This suggests that the analysis of individuals within the Palaeolithic archaeological record may be possible, but only in isolated and limited instances.

In summary, the methodology tested within this chapter was unable to trace individual knappers within the replica assemblage. Instead it displayed a clear separation between pointed and ovate handaxes, indicating that the shape of the tool influences the overall pattern of flake scars on each tool. This is repeated within the results from Foxhall Road, showing that a similar occurrence is present in the archaeological record. However, the archaeological samples studied show a further separation of handaxes based upon the overall intensity of thinning that has been applied to them. This appears to have been greatly influence by the size of each tool, which in turn has been affected by the pattern of raw material acquisition and blank choice. Therefore, it seems that a range of factors are detected that mask traces of individual idiosyncrasy and suggest that knapper adapted their knapping strategy in response to these factors, rather than following a static trajectory of reduction. However, despite this fluidity in their approach to the knapping of flint, there is arguably evidence for some form of socially mediated reduction strategy that may have subtly influenced the actions of these hominins. In addition, there are isolated cases where knapping idiosyncrasies may be present, though, while interesting, these do not further attempts to trace individual action in these assemblages. Overall, the analyses have demonstrated that Gunn's (1975) original experiments were flawed, due to the use of an assemblage with heavy restrictions imposed upon it that limited variability in size, shape and raw material. Where assemblages display more variation, each knapper follows a knapping strategy that adapts to the size and quality of the raw material, as well as the final shape that they wished to produced, and may also have been influenced by a common socially mediated template for reduction.

Chapter Nine
Discussion, Conclusions and Implications

Introduction

This thesis set out to explore the possibilities of identifying and tracing *real* individuals within the Lower Palaeolithic archaeological record. Overwhelmingly, it is has been shown that idiosyncrasies linked to individual knappers could not be reliably detected by any of the techniques presented. This chapter will now summarise and synthesise the results in order to draw forth conclusions and discuss the implications for the current theoretical stance used in the attempt to analyse the Palaeolithic archaeological record from a socially orientated viewpoint.

Imperceptible Individuals: A Summary

The analysis of the replica assemblage has clearly demonstrated the failure of the three methodologies outlined in Chapter Three to trace idiosyncrasies within either the reduction strategy or final tool form. Instead, these handaxes, in combination with the archaeological material studied, have shown that a number of other factors appear to mask the individual's input into handaxe manufacture. These primarily consist of raw material considerations, which appear to guide and influence the decisions and choices that the knapper makes throughout the knapping process (Ashton & McNabb 1994; Pettitt & White 2012; Shaw & White 2003; White 1995, 1998a). However, there is evidence that the individual is not as elusive as some would suggest. The results from the replica refitting groups indicate that some sequences produced by the same knapper do cluster together and suggests that the rotational scheme used is intrinsically linked to the knapper's approach to reduction. Also, there is evidence that handaxes produced by Knapper 1 cluster together within the scatter diagrams from the slope and flake scar analyses. This reveals that when knappers adhere to a familiar reduction strategy, as appears to be the case with Knapper 1, they tend to produce very similar end products. Despite this, Knapper 1's handaxes still fall within the range of variation seen within the rest of the assemblage and do not form a distinct cluster. Therefore, it was impossible to accurately trace their idiosyncratic imprint and isolate their products from the other tools studied.

The analysis of the handaxes from the archaeological assemblages also indicates that tools considered to be the work of a single individual do tend to cluster together. Handaxe #42 and #48 from Foxhall Road, considered to be the work of a single hominin by both Layard (1904) and White and Plunkett (2004), cluster together throughout the scatter diagrams produced during the three-dimensional and flake scar analyses. Likewise, several handaxes from Caddington that have been suggested to be linked to a single individual (Bradley & Sampson 1978) are shown to cluster frequently. Additionally, the visual analysis of the replica assemblage carried out in Chapter Five, which was based solely on gut feelings and eyeballing, was able to group together tools made by the same individual with some degree of accuracy, which suggests that the above authors may be correct when asserting that these handaxes were made by a single hominin. However, the failure of the methodologies to trace idiosyncrasies that link tools to their knapper means that there is currently no quantifiable method to conclusively prove whether these handaxes were made by the same hominin or not.

It must also be noted that comparison of the replica assemblages to the archaeological material indicates a critical flaw. By providing no restrictions to the knappers involved in the replica assemblage, a greater degree of variation in terms of the raw materials selected for use and shapes produced is evident. This does not appear to be comparable to the archaeological record, where knappers mainly used locally available raw materials, usually from a single source (Féblot-Augustins 1999), with only Foxhall Road displaying evidence of handaxes being brought on to the site (White & Plunkett 2004). Furthermore, the decision to allow the knappers to create tools solely based on their 'mood' and the properties of the raw material appears to contrast with the archaeological record, which may display evidence for the presence of socially mediate group templates that influence the knapping strategy selected for use (see below). As a result, the replica assemblage cannot be considered an accurate analogue to what is seen in the Lower Palaeolithic. As Dobres (2000: 150) reminds us, replicating the knapping techniques used in the Acheulean in this case has not provided an accurate replication of the lithic technology that was employed. If the experiments were to be repeated it would be better to select a replica assemblage that aims to provide a more accurate comparison to the archaeological assemblages being studied. However, this would necessarily involve the creation of multiple replica assemblages, each attempting to replicate the geological conditions of the archaeological assemblage under interrogations – a task that, in itself, involves myriad assumptions about raw material selection, hominin motivations, and group templates.

The analysis of three-dimensional morphology and flake scar patterning of handaxes from all of the assemblages studied highlights a further pitfall to the analysis of the individual. In both cases, treating the faces of each handaxe as separate entities demonstrates that 'genetically associated' surfaces tend not to cluster together. This demonstrates that the knappers involved did not approach the reduction of both faces of a handaxe in an identical manner, which speaks of a fluid and adaptable approach to the knapping strategy. Alteration of the technique used appears to have been caused by raw material factors and knapping mistakes, as well the desired goal. However, the fact that the methods presented in this thesis were unable to link two sides of the same tool together has serious repercussions for any study of the individual. For if we cannot even achieve this, then how can we ever hope to unravel and analyse the individual's imprint? Given the results it appears that to answer this question we must first fully understand how raw material affects the choices that the knapper has to make throughout the manufacturing process.

As the replica refitting sequences discussed in Chapter Six have shown, nodule shape and quality appear to play a significant role in guiding how the knapper approaches the reduction sequence and influencing their decisions throughout. While some nodules are able to accommodate a preferred reduction technique, many present issues that require the knapper to adjust their knapping strategy, such as incipient flaws within the raw material or protrusions that affect the initial shaping of the blank. These results suggest that later stages of the knapping process may be more valuable than others in the analysis of idiosyncratic variation. However, these stages were invariably missing from the archaeological samples studied. Instead, mainly cortical removals and initial shaping flakes make up the sequences examined, which are the stages that will be most heavily influenced by nodule shape and quality. Furthermore, the archaeology indicates that complete refitting sequences are extremely rare, even at sites with good microstratigraphic integrity, which may indicate that some stages of reduction were carried out elsewhere, or that some flakes were subsequently removed. The refitting sequence from Q/1A Unit 4b at Boxgrove is a prime example of this. This discrete scatter, which respects the outline of a hominin's legs, indicates the thinning of a previously prepared rough-out and the selection of several large flakes, interpreted as potential flake tool blanks, although in this case they were abandoned (Austin 1994; Austin *et al.* 1999).

The evidence from the other methodologies tested continues to suggest that raw material factors contribute greatly to overall tool form. Results from the three-dimensional analyses indicated that the shape of the tools is a primary source of variation. In the case of the aspect analysis, the detection of a division due to shape is likely to be a methodological issue, caused by the analysis of the three-dimensional point cloud data. As previously discussed, differences in butt and tip area result in different weightings for the northern and southern orientations of each handaxe's topography. However, analysis of the aspect data has shown that tools tend to conform to a standard within assemblages and those that are outliers tend to be tools that are cruder and display limited flaking. The slope data, however, appears much more reliable. In this case, division of the tools according to shape occurs due to the fact that ovate tools generally display fewer areas with steep topography, indicating that they are more intensively thinned, while, in contrast, pointed tools tend to be thicker, resulting in higher slope values caused by their more angular surfaces.

Division of the handaxes based on shape is most clearly seen in both the replica and Foxhall Road assemblages. However, this is less evident in the handaxes from Boxgrove and Caddington. It is suggested that the division based on shape is accentuated in the replica and Foxhall Road assemblages due to the greater variety in tool form that they display. The Boxgrove and

Caddington assemblages, on the other hand, contain greater numbers of ovate handaxes compared to pointed forms. In addition, it has been demonstrated that several of the tools classed as points within these assemblages are considered to be cordiforms, indicating issues in the reliance on a measurement based typology. However, given the fact that raw material often has a great effect on the resultant shape of a handaxe (Ashton & McNabb 1994; White 1998a), the division according to tool form may be linked to raw material considerations. This is especially evident at Foxhall Road, where cruder pointed handaxes are made on small flint pebbles, while larger and more refined ovate tools are produced on larger modules or flakes (White & Plunkett 2004).

The results from the scar pattern analysis indicate that size of the tools is also an important factor within the archaeological samples studied. Closer examination of the handaxes also shows that the size of the original nodule has a large influence over final tool size. By extension, nodule size affects the decisions that hominins made during reduction and final thinning, primarily concerning the extent of flaking that can be applied. This is reflected by the fact that handaxes made from smaller nodules or flint pebbles generally display lower intensities of flaking with some cortex retention, while larger raw material allows for extended reduction and more intensive thinning.

Raw material concerns may also be the reason for the division of the Palaeolithic Floor and Contorted Drift assemblages from Pit C displayed in the results from the three-dimensional analysis. Although the quality of flint is comparable, these two assemblages appear to consist of contrasting nodule types, which adds weight to Bradley and Sampson's (1978) conclusion that the tools from the Contorted Drift are part of a derived assemblage. This is in some ways similar to what White and Plunkett (2004) have shown at Foxhall Road, and clearly demonstrates that the tools from these two contexts must be treated separately in future studies. In addition, discrepancies were noted between the museum catalogue that was used and the information from Smith's (n.d.) List of Palaeolithic Implements, which must be addressed to aid further research.

Besides indicating that raw material properties increase the difficulties of identifying and tracing idiosyncratic actions in the material record, the results from the Caddington handaxes are perhaps the most interesting out of the archaeological samples studied. This is due to the possibility that this assemblage presents evidence for socially mediated group templates that influence the reduction strategy. Differentiating the tools according to the brickearth pits that they originated from clearly shows a separation between some of the pits when the flake scar patterning is studied. While this separation may be due to a temporal factor (although the exact date of deposition for each pit cannot be determined at present) the fact remains that groups of hominins at Pits E and F were producing handaxes in subtly different ways to hominins at Pits A, C and G. The argument for group templates is strengthened by the results from the Boxgrove Unit 4/3 and 4u assemblages. These continually display strong levels of standardisation, with handaxes clustering tightly together when scatter diagrams are produced. Only tools that do not conform to this apparent standard are shown to be outliers. Therefore, it appears possible that the hominins at Boxgrove may have conformed to socially defined models of handaxe production. It is unlikely that this was introduced by the raw material available, which is of good quality and generally affords freedom of reduction to the knapper. Instead, it is suggested that this standard was introduced on a more social level, which, until now, has been lost in the view that the Acheulean was a period of technological stagnation that persisted unchanged for an immense period of time (Hopkinson & White 2005). This view is strengthened when the short time scale in which the artefacts were deposited is taken into consideration (see Chapter Four) and may also begin to inform us further about the transmission of learned behaviour and the overall patterning seen in the Acheulean as a whole (see Chapter Two). It may also be pertinent here to consider other examples of localised ‘micro-traditions’ in handaxe form and production, such as Broom (Hosfield & Chambers 2009), which do not appear to be linked to raw material conditioning. This suggests the possibility that group templates may also be discovered outside of sites that display homogeneity in the available raw materials.

VISIBLE GROUPS?

The question now is whether socially mediated group templates are visible on an inter-site scale. It is entirely possible that they are subsumed within the variation present within the Acheulean. This variation is more commonly attributed to differences in the raw material available, which this thesis confirms, and has led some to suggest the complete absence of a socially defined template that guides reduction (see Ashton & McNabb 1994). However, evidence from the analysis of the archaeological material presented in this thesis argues against this standpoint. The data from Caddington especially appears to support notions that hominins selected from a 'pool' of knapping options that were available to them, choosing variable methods of reduction based on their individual preferences and abilities, as well as the properties of the materials available to them. This then speaks of a flexible approach to tool manufacture, which is in agreement with other studies that argue against a *fixed* mental template being involved in handaxe manufacture (Gowlett 2006b). However, this does not preclude the involvement of such flexible expressions of knapping that occur throughout the Acheulean from having a socially informed component that extends beyond influences from other sources of variation, such as raw material properties. Indeed, White (2006a) has suggested that there are clear design elements in place during the production of tools that correspond to the involvement of elaborate planning and cognitive processes. Therefore, it is proposed here that the notion of a social mediated 'template' involved in tool production should not be confused with a rigid determination of how a tool should both look and act. Instead, such a template would provide a social informed, but flexible mode of tool production, which was able to be adapted to the specific needs that would beset the tool maker during the act of manufacture (Gowlett 2006b). While the analysis of the Caddington and Boxgrove assemblages certainly hints that such a socially informed template may be present, one must ask why this has been so strongly questioned over the last twenty years. In order to explore this question, a brief inter-site comparison of the archaeological assemblages was conducted.

Handaxes from all three sites were analysed using the methodologies for analysing slope data and flake scar patterning. Aspect data was not used, as the results from Chapter Seven indicate that this form of analysis is methodologically flawed. In addition, only whole unit data was analysed. Principal component analysis was used to extract those components that explain the majority of the variance, the results of which are similar to those extracted from the analyses presented in Chapters Seven and Eight (see Tables 9.1 and 9.2). Scatter diagrams were then produced to explore the results in detail (see Figures 9.1-9.4).

These scatters clearly show that the assemblages do not form into discrete clusters and display a high degree of overlap. When examining the results from the analysis of the slope data, however, it is notable that the majority of the handaxes from Boxgrove sit to the left of the scatters in Figures 9.1 and 9.2. The handaxes from Caddington, on the other hand, are found on the right, while the tools from Foxhall Road spread between the two. This could be interpreted as very subtle differences based on contrasting group templates. However, there is a stark contrast in the raw materials that were used at each site. Boxgrove displays the use of good quality nodules extracted from the nearby chalk cliff face (Roberts & Parfitt 1999), while at Caddington hominins utilised four different types of flint at Pit C alone (Bradley & Sampson 1978), with evidence for the presence of a range of tabular and sub-spherical nodules of varying qualities. Finally, Foxhall Road indicates that hominins brought in larger, premade ovates, and used local flint gravels to produce smaller and less refined tool on site (White & Plunkett 2004). Therefore, given the disparity in raw material between the three sites, it is much more likely that this division is due to differences in the flint that was available for reduction. This conclusion explains why part of the Foxhall Road assemblage, namely those handaxes that are of larger ovate form and intensively thinned, cluster with the Boxgrove assemblage.

The result from the analysis of the flake scar patterning is similar (see Figure 9.4). Again, there is a high degree of overlap present between the three sites. However, handaxes from Boxgrove are situated to the right of the scatter, while tools from Foxhall Road and Caddington are found across the left and centre respectively. Again, one could argue for the presence of a subtle difference in scar patterning that may be influenced by a socially mediated ideal of how the knapping strategy must proceed. However, the results of the analyses discussed in Chapter Eight highlighted the fact that component one is correlated to the intensity of thinning applied, which is informed by the size of the raw material selected for reduction. The results of this analysis are no different. It can therefore be demonstrated that the handaxes that fall on the left of the scatter are smaller and less intensively thinned, while those on the right are larger and generally display a higher degree of flaking. As a result, the pattern seen within the scatter can also be attributed to differences in the available raw material at these sites, as opposed to the presence of differing group templates.

The above inter-site comparison clearly demonstrates that raw material properties have a large impact upon the final form of the handaxes studied. Yet the evidence from the analysis of the Caddington assemblage cannot be ignored. It is suggested that the differences in scar patterning seen between the brickearth pits studied, and by extension the method of reduction used, may have been detected due to the fact that the hominins present at the Caddington brickearth pits were utilising relatively similar raw material sources. However, both of the scatter diagrams discussed above appear to indicate a continuum of variation at the inter-site level and while group templates may be present, these are concealed by time averaging and the properties of the flint selected for reduction. In other words, this appears to be Isaac's (1972) random drift model writ large.

This has immediate resonance for the study of the hominin individual. It appears that any method of reduction that has been socially defined is only detectable at sites that have been extensively used by different groups of hominins who accessed similar raw material sources. At the inter-site level their flexible mental templates were constantly being redefined by differences in locally available raw material, which forced hominins to adapt any predefined knapping strategy in order to achieve their goals. Thus, we would expect to see regular drift within reduction modes due to the suggested mobility of hominins as they traversed between nodal points within their localised landscapes of habitat (Gamble 1999), as well as the general passage of time. Such an interpretation has strong implications for how we view local variability and the wider patterning in the Acheulean. Local scale variation within the British Lower Palaeolithic has been attributed to chronological patterning, potentially as a result of repeated colonisation and extinction events (see Chapter Two). The evidence seen would seem to support this view, with the added caveat that such variation may stem from changes in group structure. This would also be a potential explanation for the presence of local variations, such as the twisted ovate (White 1998b; White & Schreve 2000). On a wider scale, the phylogenetic drift seen within the global patterning of the Acheulean (Lycett 2009) may also be linked to concepts of group movements and the social transmission of learned behaviour. However, the utilisation of localised resources, proved by raw material studies and the context of the sites under review here, suggests that hominins had to overcome the raw material constraints relative to the resources that were locally available in order to meet the set of needs that were required. As Gowlett (2006b) notes, the imperatives involved in the manufacture of a tool lead to a pointer being positioned within a field of variation, resulting in the continuous variation seen within the Acheulean record and a lack of strong modalities being present. In addition, it is possible that the limited range of options available to hominins, combined with the requirement to meet specific needs, would have limited to the range of forms that could be selected from, thus restricting the development of individual or group styles. As Nowell and White (2010) have postulated, the locality of social life and low group membership within the Lower Palaeolithic would have limited the wide ranging transmission of innovations, thus leading to isolated and short lived instances of highly variable behaviour being transmitted, probably learnt through a many-to-one process (Lycett & Gowlett 2008), which subsequently vanished as this group went extinct. Overall, therefore, we do not see different socially mediated modes of reduction, but rather detect contrasts in the materials that were utilised at localised nodal points within short ranging landscapes of habit. Subsumed within this are the individuals themselves, whose actions appear to be guided by society, but must mitigate the limitations of the raw material in the manufacture of a useable end product. Therefore, the variability of the Acheulean is considered to be the result of individual action, which is mediated by society and adapted to the nature of the lithic material chosen for reduction. In many ways, we can draw parallels between these concepts and the social behaviour seen in our societies today. However, as McNabb (2007) notes, we cannot conceive of Lower Palaeolithic hominins being the same as us. While it is tempting to try and compare modern social behaviour to that of *Homo heidelburgensis*, it is important not to fall readily into this trap. As yet, it appears that the interplay between the factors that were instrumental in determining hominin behaviour are not fully understood. If our goal is to produce a meaningful analysis that is orientated from the bottom up, then further work is needed to tease these elements apart in the hope that they can be better understood.

IMPLICATIONS FOR A SOCIALLY ORIENTATED ANALYSIS

In Chapter Two it was demonstrated that the isolation of events brought about by an individual's agency, such as refitting scatters, prevents the understanding of how these relate to the social structures that encompass them (after Hodder 2000). Under such circumstances, we can demonstrate one individual's agency, but are unable to fathom the agency of others, nor produce meaningful interpretations of the social world that they were situated within. Instead we must show how individuals interacted with one another, their groups and wider societies. Therefore, despite arguments to the contrary (Dobres 2000; Dobres & Robb 2000; Redman 1977; Sassaman 2000), we must strive to trace the actions of individuals. Doing so will reconnect agency to the actor, allowing for the study of the single agent, their actions and how these relate to others within the wider social network.

The results presented in this thesis clearly show that, at present, the possibilities of isolating individual hominins in the Lower Palaeolithic record are extremely limited. It appears that any idiosyncrasies that were introduced into handaxe manufacture and final tool form are obscured by variability in the materials selected and the way that these influenced reduction. Additionally, although the possibility of group templates is evidenced within the Caddington assemblage, any socially mediated knapping strategy cannot be demonstrated between sites due to variations in locally available raw material. This variability overshadows and guides the actions of both the group and the individuals within it. The results, therefore, indicate that differences in the lithic material selected by hominins is the primary factor in preventing their choices and decisions from being accurately observed. What we must now consider is how this impacts upon the struggle for a socially orientated analysis of the Palaeolithic archaeological record.

Firstly, it is clear that a bottom up approach to the Palaeolithic archaeological record is currently untenable, due to the fact that we cannot accurately trace the actions of individual hominins. As a result, we are unable to demonstrate definitively how individuals constructed themselves within their societies and how those societies influenced them in return. Secondly, we are unable to adequately test the hypotheses suggested by our socially orientated interpretations of the material record. Hence, these do not allow us to produce meaningful discourse that aids our understanding of the Palaeolithic. Instead they provide a means to conceive of how individuals related themselves to one another, a *way of thinking* if you will, which does not help to truly unravel the intricacies of the archaeological record. In addition, these theories are often rooted in the way we understand and perceive of our own social worlds. It is not enough to suggest, as Gamble (2010) has done, that how we conceptualise our own social arena mirrors, by extension, how hominins comprehended their own sociality. As Hopkinson and White (2005) rightly state, though the Acheulean is a structurated practice, "it [is] clearly of a different kind from those seen in contemporary Western societies". Therefore, we must continue to search for evidence of how hominins perceived of themselves and the others around them. The only way to do so is through the exploration of the archaeological record and rigorous testing of our theoretical frameworks.

It should be noted, however, that this thesis does not advocate the complete abandonment of social theory, or its application to the Palaeolithic. Instead, it stresses that we should begin to accept that our theories only provide a means to ponder upon the material record, rather than present accurate interpretations that advance our studies further. Therefore, we should begin to seek out new methods of analysing archaeology that permit us to test our theories and improve our hypotheses, as opposed to allowing our studies to stagnate in a morass of theoretical viewpoints.

On a more positive note, the methodologies detailed within this thesis have begun to reveal aspects within the artefact forms and knapping methodologies seen within the Lower Palaeolithic that have previously gone undetected by more traditional quantifiable and qualitative approaches to tool analysis (e.g. Bordes 1961; Debénath & Dibble 1994; Roe 1968; Wymer 1968). They have shown the potential to detect certain idiosyncratic traits that may have operated at either the group or individual level. Analysis of flake scar orientation demonstrates the potential for a more in depth study that highlights differences in approaches to tranchet flaking and morphological variations such as the twisted ovate. The study of the refitting sequences, particularly in regards to the analysis of the replica assemblage, has shown how rotation during knapping is linked to choices at the individual level and highlights this trait as a source of idiosyncrasy that may lead to a greater understanding of hominin approaches to tool production. In addition, this form of analysis also suggests that the ability to correct knapping errors and the manner in which this is done also presents a window towards an individual's own approach. Despite this, analysis of the archaeological material displays the limitations of recovered refitting sequences in regards to any study addressing the individual, due to their frequently short nature and the relative absence of thinning flakes, which are suggested to be vital in indicating hominin choice processes on a finer level when compared to initial stages of reduction.

The methodologies and the analytical processes within them also have potential value in the detection of extreme outliers that display a high degree of variability in comparison to the rest of an assemblage. This is of great importance in guiding further study by enabling these tools to be detected and analysed in greater detail in order to determine the source of their variability and why they appear distinct from other members within the body of an assemblage. In addition, the analyses have shown how a combination of detailed results, visual impressions of the tools and the addition of contextual data can help enhance the understanding of both experimental and archaeological material. To emphasise this point, as discussed throughout the thesis, it was notice during the analysis of the experimental data that handaxes produced by Knapper 1 had a tendency to cluster. Following the analysis an in depth visual assessment of the tools was conducted in an attempt to determine any form of idiosyncrasy that might be present. Here it was noticed that several of the handaxes attributed to Knapper 1 displayed similar concentrations of step and hinge fractures, leaving a localised platform within the flint that was generally confined to the lower left-hand side of one face. Later, when the knapper was contacted, observation of other examples of this individual's work showed that this feature was a common occurrence and, although it did not appear in every instance, appeared to be an idiosyncratic trait specific to their work. Likewise, the analysis of the assemblages from the Caddington brickearth pits in correlation with the contextual data available has shown how possible temporal differences between the depositions of these artefacts might be a primary explanation behind the patterning seen.

CONCLUSIONS

The overarching conclusion of this research is the demonstration that unmasking the individual within the Palaeolithic archaeological record, and by extension, the intentions and relationships that they wished to express, is as exceedingly complex as Clark (1992) originally claimed. Despite understanding that they are fundamentally responsible for the production of the handaxes that we recover, hominins are more often than not swallowed by the variability of the Acheulean, which appears to be informed more by the influences of the stones selected for reduction, than the individual's desire to express themselves (c.f. Kohn & Mithen 1999). The possibility of detecting socially mediated group templates at the inter-site level may be limited by the variable nature of the raw material sources available, although there is scope for such studies depending on the nature of the sites that are discussed. The fact that groups may have influenced the actions of the hominins that they encapsulated is exceptionally important and begins to refute the way in which the influences that structured the knapping processes have previously be understood (e.g. Ashton & McNabb 1994). Moreover, this suggests that an understanding of the group dynamic is as important as the individual and should not be pushed aside (c.f. Gamble 1999, 2007; Gamble & Gittins 2004).

Furthermore, in terms of our understanding of how social theory is applied to Palaeolithic archaeology, the implications of this research illustrate that such theoretical viewpoints should not be regarded as fact. Future research must aim to go beyond "bald assertions that *all* technology *is* social mediation" (Pettitt & White 2012: 161, original emphasis). To do so, we must aim to reintegrate our theories with the analysis of the archaeological record in order to refine and amend our viewpoints in a cyclical fashion. However, we must first begin to tease apart the interplay between the intentions of hominins, the nature of the group and the influences of raw materials before a comprehensive understanding of the role that Acheulean handaxes and the individuals who created them played in mediating the social relationships of the Palaeolithic.

REFERENCES

Aiello, L. C. & Dunbar, R. 1993. Neocortex size, group size and the evolution of language. *Current Anthropology* 34: 184-193.

Amick, D. S., Mauldin, R. P. & Binford, L. R. 1989. The Potential of Experiments in Lithic Technology. In D. S. Amick & R. P. Mauldin (eds) *Experiments in Lithic Technology:* 1-14. B.A.R. International Series S528.

Andrefsky, W. 2005. *Lithics: Macroscopic Approaches to Analysis (Second Edition).* Cambridge University Press, Cambridge.

ApSimon, A. M., Gamble, C. & Shackley, M. L. 1977. Pleistocene raised beaches on Portsdown, Hampshire. *Proceedings of the Hampshire Field Club* 33: 17-32.

Asfaw, B., Beyene, Y., Suwa, G., Walter, R. C., White, T. D., WoldeGabriel, G. & Yemane, T. 1992. The earliest Acheulian from Konso-Gardula. *Nature* 360: 732-735.

Ashton, N. & Lewis, S. G. 2002. Deserted Britain: declining populations in the British Late Middle Pleistocene. *Antiquity* 76: 388-396.

Ashton, N. & Lewis, S. G. 2012. The environmental contexts of early human occupation of northwest Europe: The British Lower Palaeolithic record. *Quaternary International* 271: 50-64.

Ashton, N., Lewis, S. G., Keen, D. H. & Parfitt, S. A. 2000. Excavations at Elveden, Suffolk (TL 809804). In S. G. Lewis, C. A. Whiteman & R. C. Preece (eds) *The Quaternary of Norfolk and Suffolk, QRA Field Guide:* 177-184. Quaternary Research Association, London.

Ashton, N., Lewis, S. G. & Parfitt, S. A. (eds). 1998. *Excavations at the Lower Palaeolithic site at East Farm, Barnham, Suffolk, 1989-94*. British Museum Press (Occasional Paper 125), London.

Ashton, N. & McNabb, J. 1994. Bifaces in Perspective. In N. Ashton & A. David (eds) *Stories in Stone:* 182-191. Lithic Studies Society, London.

Ashton, N. & White, M. J. 2003. Bifaces and Raw Materials: Flexible Flaking in the British Early Palaeolithic. In M. Soressi & H. L. Dibble (eds) *Multiple Approaches to the Study of Bifacial Technologies:* 109-123. Museum of Archaeology and Anthropology, University of Pennsylvania.

Austin, L. A. 1994. The Life and Death of a Boxgrove Biface. In N. Ashton & A. David (eds) *Stories in Stone:* 119-126. Lithic Studies Society, London.

Austin, L. A., Bergman, C. A., Roberts, M. & Wilhelmsen, K. H. 1999. 6.2 Archaeology of the excavated areas. In M. Roberts & S. A. Parfitt (eds) *Boxgrove: a middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex:* 312-378. English Heritage, London.

Avery, B. W., Bullock, P., Catt, J. A., Rayner, J. H. & Weir, A. H. 1982. Composition and Origin of some Brickearths on the Chiltern Hills, England. *Catena* 9: 153-174.

Bahn, P. G. 1991. Thoughtful foragers: a study of prehistoric decision making by Steven J. Mithen. *Antiquity* 65(1): 158-160.

Balme, J. & Morse, K. 2006. Shell beads and social behaviour in Pleistocene Australia. *Antiquity* 80(4): 799-809.

Bar-Yosef, O. 1998. Early colonizations and cultural continuities in the Lower Palaeolithic of Western Asia. In M. D. Petraglia & R. Korisettar (eds) *Early Human Behaviour in Global Context: the Rise and Diversity of the Lower Palaeolithic Record:* 225-279. Routledge, London.

Bar-Yosef, O. 2001. In the quest for palaeolithic human behaviour. In S. Milliken & J. Cook (eds) *A very remote period indeed: papers on the palaeolithic presented to Derek Roe:* 96-104. Oxbow, Oxford.

Barham, L. 2002. Systematic pigment use in the MIddle Pleistocene of South-Central Africa. *Current Anthropology* 43: 181-190.

Barrett, J. 1988. Fields of Discourse: Reconstituting a Social Archaeology. *Critique of Anthropology* 7: 5-16.

Barrett, J. 1993. *Fragments from Antiquity: Archaeology of Social Life in Britain, 2900-1200 BC.* Blackwell, Oxford.

Barrow, G. 1919. Some future work for the Geologists' Association. *Proceedings of the Geologists' Association* 30: 1-48.

Barsky, D. & de Lumely, H. 2010. Early European Mode 2 and the stone industry from the Caune de l'Agaro's archaeostratigraphical levels 'P'. *Quaternary Science Reviews* 223/224: 71-86.

Bednarik, R. G. 1998. The 'Austrolapithecine' cobble from Makapansgat, South Africa. *South African Archaeological Bulletin* 53: 4-8.

Bednarik, R. G. 2005. Middle Pleistocene Beads and Symbolism. *Anthropos* 100(2): 537-552.

Bellomo, R. V. & Kean, W. F. 1972. Evidence of hominid-controlled fire at FxJj20 site complex, Karari Escarpment. In G. L. Isaac & B. Isaac (eds) *Koobi Fora Reserach Project, (Vol. 5): Plio-Pleistocene Archaeology:* 224-233. Clarendon Press, Oxford.

Binford, L. R. 1962. Archaeology as Anthropology. *American Antiquity* 28: 217-225.

Binford, L. R. 1965. Archaeological systematics and the study of the culture process. *American Antiquity* 31: 203-210.

Binford, L. R. 1968. Archaeological Perspectives. In L. R. Binford & S. R. Binford (eds) *New Perspectives in Archaeology:* 5-32. Aldine, New York.

Binford, L. R. 1977. *For theory building in archaeology.* Academic Press, New York.

Binford, L. R. 1983. *In Pursuit of the Past.* Thames and Hudson, New York.

Binford, L. R. 2001. *Constructing frames of reference: an analyrical method for archaeological theory building using hunter-gatherer and environmental data sets.* University of California Press, Berkley.

Bodu, P., Karlin, C. & Ploux, S. 1990. Who's Who? The Magdalenian Flintknappers of Pincevent, France. In E. Cziesla, S. Eickhoff, N. Arts & D. Winter (eds) *The Big Puzzle: International Symposium on Refitting Stone Artefacts, Monrepos, 1987:* 143-163. Holos, Bonn.

Bordes, F. 1961. *Typologie du Paléolithique Ancien et Moyen.* Editions de Centre national de la recherche scientifique, Paris.

Bordes, F. 1968. *The Old Stone Age.* Weidenfield and Nicolson, London.

Bordes, F. 1981. Vingt-cinq ans après: le complexe Moustérien revisité. *Bulletin de la Société Préhistorique Française* 78: 77-87.

Boswell, P. G. H. & Reid Moir, J. 1923. The Pleistocene Deposits and Their Contained Palaeolithic Implements at Foxhall Road, Ipswich. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 53: 229-262.

Boucher-de-Perthes, J. 1847-1864. *Antiquités celtiques et antédiluviennes: Mémoirs sur l'industrie primitive et les arts à leur origine (Three Volumes).* Treuttel et Wurtz, Paris.

Bourdieu, P. 1990. *The Logic of Practice.* Stanford University Press, Stanford.

Bradbury, A. P. & Carr, P. J. 1999. Examining Stage and Continuum Models of Flake Debris Analysis: An Experimental Approach. *Journal of Archaeological Science* 26: 105-116.

Bradley, B. & Sampson, C. G. 1978. Artifacts from the Cottages Site. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 83-137. Department of Anthropology, Southern Methodist University, Dallas.

Bradley, B. & Sampson, C. G. 1986. Analysis by replication of two Acheulean artefact assemblages. In G. N. Bailey & P. Callow (eds) *Stone Age Prehistory: Studies in memory of Charles McBurney:* 29-45. Cambridge University Press, Cambridge.

Brain, C. K. 2005. Essential attributes of any technologically competant animal. In F. d'Errico & L. Backwell (eds) *From tools to symbols: from early hominids to modern humans*. Witwatersrand University Press, Johannesburg.

Brain, C. K. & Sillen, A. 1988. Evidence from the Swartkrans cave for the earliest use of fire. *Nature* 336: 464-466.

Bratlund, B. 1999. Taubach Revisited. *Jahrbuch des Romish-Germanischen Zentralmuseums Mainz* 46: 61-174.

Bridgland, D. R. 1994. *Quaternary of the Thames.* Chapman and Hall, London.

Bridgland, D. R. & Harding, P. 1989. Investigations at Gaddesden Row Brickpit, Hertfordshire. *Quaternary Newsletter* 39: 2-4.

Busby, C. 1997. Permeable and Partible Persons: A Comparative Analysis of Gender and Body in South India. *Journal of the Royal Anthropological Institute* 3(2): 261-278.

Butler, B. R. 1963. An early man site at Big Camas Prairie, South Central Idaho. *Tebiwa* 6: 22-33.

Butler, C. 2005. *Prehistoric Flintwork.* Tempus Publishing Ltd., Stroud.

Cahen, D. & Keeley, L. H. 1980. Not Less than Two, Not More than Three. *World Archaeology* 12(2): 166-180.

Cahen, D., Keeley, L. H. & Van Noten, F. L. 1979. Stone Tools, Toolkits, and Human Behavious in Prehistory. *Current Anthropology* 20(4): 661-683.

Calkin, J. B. 1934. Implements from the Higher Raised Beaches of Sussex. *Proceedings of the Prehistoric Society of East Anglia* 7: 333-347.

Campbell, J. B. & Hubbard, R. N. L. B. 1978. Biological Investigations of the Rackley Site. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 47-60. Department of Anthropology, Southern Methodist University, Dallas.

Campbell, J. B. & Sampson, C. G. 1978. The Cottages Site. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 61-81. Department of Anthropology, Southern Methodist University, Dallas.

Candy, I., Rose, J. & Lee, J. R. 2006. A seasonally 'dry' interglacial climate in eastern England during the early Middle Pleistocene: palaeopedological and stable isotope evidence form Pakefield, UK. *Boreas* 35: 255-265.

Carbonell, E., Bermudez de Castro, J. M., Arsuaga, J. L., Diez, J. C., Rosas, A., Cuenca-Bescós, G., Sala, R., Mosquera, M. & Rodriguez, X. P. 1995. Lower Pleistocene hominids and artifacts from Atapuerca-TD6 (Spain). *Science* 269: 826-829.

Catt, J. A. 1978. Sediments from the Rackley Site. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 39-46. Department of Anthropology, Southern Methodist University, Dallas.

Catt, J. A., Hubbard, R. N. L. B. & Sampson, C. G. 1978. Summary and Conclusions. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England*. Department of Anthropology, Southern Methodist University, Dallas.

Cavalli-Sforza, L. L. & Feldman, M. W. 1981. *Cultural Transmission and Evolution: A Quantitative Approach.* Princeton University Press, Princeton.

Chapman, J. 2000. *Fragmentation in archaeology: people, places and broken objects in the prehistory of south-eastern Europe.* Routledge, London.

Chapman, J. & Gaydarska, B. 2006. *Parts and Wholes: Fragmentation in its Prehistoric context.* Oxbow Books, Oxford.

Chase, P. G. 1991. Symbols and Palaeolithic Artifacts: Style, Standardization, and the Imposition of Arbitrary Form. *Journal of Anthropological Archaeology* 10: 193-214.

Chase, P. G. 2006. *The Emergence of Culture: The Evolution of a Uniquely Human Way of Life.* Springer.

Childe, V. G. 1956. *Society and Knowledge.* Harper Brothers, New York.

Chu, W. 2009. A functional approach to Paleolithic open-air habitation structures. *World Archaeology* 41(3): 348-362.

Clark, G. A. 1992. A Comment on Mithen's Ecological Interpretation of Palaeolithic Art. *Proceedings of the Prehistoric Society* 58: 107-109.

Clark, J. G. D. 1977. *World Prehistory: illustraded third edition.* Cambridge University Press, Cambridge.

Clarke, D. L. 1973. Archaeology: the loss of innocence. *Antiquity* 47: 6-18.

Clarkson, C., Vinicius, L. & Mirazón Lahr, M. 2006. Quantifying flake scar patterning on cores using 3D recording techniques. *Journal of Archaeological Science* 33: 132-142.

Conard, N. J. & Adler, D. S. 1997. Lithic Reduction and Hominid Behavior in the Middle Paleolithic of the Rhineland. *Journal of Anthropological Research* 53(2): 147-175.

Coolidge, F. L. & Wynn, T. 2009. *The Rise of Homo sapiens: The evolution of modern thinking.* Wiley-Blackwell, Oxford.

Cotterell, B. & Kamminga, J. 1987. The Formation of Flakes. *American Antiquity* 52(4): 675-708.

Crompton, R. H. & Gowlett, J. A. J. 1993. Allometry and multidimensional form in Acheulean bifaces from Kilombe, Kenya. *Journal of Human Evolution* 25: 175-199.

Cross, J. R. 1983. Twigs, Branches, Trees and, Forests: Problems of Scale in Lithic Analysis. In J. A. Moore & A. S. Keene (eds) *Archaeological Hammers and Theories:* 87-106. Academic Press, New York.

Curwen, E. 1925. Palaeolith from raised beach in Sussex. *The Antiquaries Journal* 5: 72-73.

d'Errico, F. & Nowell, A. 2000. A new look at the Berekhat Ram figurine: Implications for the origins of symbolism. *Cambridge Archaeological Journal* 10: 123-167.

Daniel, G. 1950. *A Hundred Years of Archaeology.* Riverside Press, Edinburgh.

Daniel, G. 1981. *A Short History of Archaeology.* Thames and Hudson, London.

Daniel, G. & Renfrew, C. 1988. *The Idea of Prehistory.* Edinburgh University Press, Edinburgh.

Dart, R. A. 1974. The waterworn Australopitheciine pebble of many faces from Makapansgat. *South African Journal of Science* 70: 167-169.

Davidson, I. & Noble, W. 1993. Tools and Language in Human Evolution. In K. R. Gibson & T. Ingold (eds) *Tools, Language and Cognition in Human Evolution:* 363-388. Cambridge University Press, Cambridge.

Davis, J. C. & Preston, F. W. 1971. Size distributions by optical Fourier analysis. In Proceedings of the Third International Congress for Stereology. *Proceedings of the Royal Microscopical Society* 6: 12-13.

de Beaune, S. A. 2009. Technical invention in the Palaeolithic: What if the explaination comes from the cognitive and neuropsychological sciences? In S. A. de Beaune, F. L. Coolidge & T. Wynn (eds) *Cognitive Archaeology and Human Evolution:* 3-14. Cambridge University Press, Cambridge.

de Mortillet, G. 1891. Mousterien des environs de Mons. *Bulletin de la Société d'Anthropologie de Paris* 2: 565-568.

Debénath, A. & Dibble, H. L. 1994. *Hanbook of Palaeolithic Typology Volume One: Lower and Middle Paleolithic of Europe.* University of Pennsylvania, Museum of Archaeology and Anthropology, Philadelphia.

Dennell, R. 2003. Dispersal and colonisation, long and short chronologies: how continuous is the Early Pleistocene record for hominids outside East Africa? *Journal of Human Evolution* 45: 421-440.

Dennell, R. 2004. *Early Hominin Landscapes in Northern Pakistan.* Archaeopress. British Archaeological Reports International Series 1265, Oxford.

Dennell, R., Rendell, H. M. & Hailwood, E. 1988. Early tool-making in Asia: two-million year-old artefacts in Pakistan. *Antiquity* 62: 98-106.

Dennell, R. & Roebroeks, W. 1996. The earliest colonization of Europe: the short chronology revisited. *Antiquity* 70: 535-542.

Dibble, H. L. 1984. Interpreting Typological Variation of Middle Paleolithic Scrapers: Function, Style, or Sequence of Reduction? *Journal of Field Archaeology* 11(431-436).

Dibble, H. L. 1987. The Interpretation of Middle Paleolithic Scraper Morphology. *American Antiquity* 52: 109-117.

Dibble, H. L. 1991. Local Raw Material Exploitation and its Effects on Lower and Middle Palaeolithic Assemblage Variability. In A. Montet-White & S. Holen (eds) *Raw Material Economies among Prehistoric Hunter-Gatherers:* 33-47. University of Kansas Publications in Anthropology, Lawrence.

Dibble, H. L. 1995. Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date. *Journal of Archaeological Method and Theory* 2: 299-368.

Dibble, H. L. & Bernard, M. C. 1980. A Comparative Study of Basic Edge Angle Measurement Techniques. *American Antiquity* 45(4): 857-865.

Dibble, H. L. & Pelcin, A. 1995. The Effect of Hammer Mass and Velocity on Flake Mass. *Journal of Archaeological Science* 22: 429-439.

Dibble, H. L. & Whittaker, J. C. 1981. New Experimental Evidence on the Relation Between Percussion and Flake Variation. *Journal of Archaeological Science* 8: 283-296.

Dobres, M.-A. 2000. *Technology and Social Agency.* Blackwells, Oxford.

Dobres, M.-A. & Robb, J. 2000. Agency in Archaeology: Paradigm or platitude? In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 3-17. Routledge, London.

Donald, M. 1991. *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition.* Harvard University Press, London.

Dunbar, R. 1992. Neocortex size as a constraint on group size in primates. *Journal of Human Evolution* 20: 469-493.

Dunbar, R. 1993. Coevolution of neocortical size, group size and language in humans. *Behavioural and Brain Sciences* 16: 681-735.

Dunbar, R. I. M. 1998. The Social Brain Hypothesis. *Evolutionary Anthropology* 6(5): 178-190.

Dunbar, R. I. M. 2003. The Social Brain: Mind, Language, and Society in Evolutionary Perspective. *Annual Review of Anthropology* 32: 163-181.

Dunbar, R. I. M. 2004. *The Human Story.* Faber and Faber, London.

Dunbar, R. I. M. 2007. The Social Brain and the Cultural Explosion of the Human Revolution. In P. Mellars, K. Boyle, O. Bar-Yosef & C. B. Stringer (eds) *Rethinking the Human Revolution:* 91-98. MacDonald Institute Monographs, Cambridge.

Dunnell, R. C. 1978. Style and Function: A Fundamental Dichotomy. *American Antiquity* 43(2): 192-202.

Edwards, S. W. 2001. A modern knapper's assessment of the technical skills of the Late Acheulean biface workers at Kalambo Falls. In J. D. Clark (ed.) *Kalambo Falls Prehistoric Site III:* 605-611. Cambridge University Press, Cambridge.

Evans, J. 1860. On the Occurence of Flint Implements in undisturbed Beds of Gravel, Sand, and Clay. *Archaeologia* 38: 280-307.

Evans, J. 1897. *The Ancient Stone Implements, Weapons and Ornaments, of Great Britain.* Longmans, Green and Co., London.

Féblot-Augustins, J. 1999. Raw material transport patterns and settlement systems in the European Lower and Middle Palaeolithic: continuity, change and variability. In W. Roebroeks & C. Gamble (eds) *The Middle Palaeolithic Occupation of Europe*. University of Leiden, Leiden.

Foulds, F. W. F. 2010. Investigating the Individual? An Experimental Approach through Lithic Refitting. *Lithics* 31: 6-19.

Fowler, J. 1932. The 'One Hundred Foot' Rasied Beach between Arundel and Chichester, Sussex. *Quarterly Journal of the Geological Society of London* 88: 84-99.

Frere, J. 1800. Account of Flint Weapons discovered at Hoxne in Suffolk. *Archaeologia* 13: 204-205.

Fridrich, J. 1989. *Prezletice: A lower palaeolithic site in Central Bohemia (Excavations 1969-1985).* Museum Nationale Pragae, Pragae.

Friedman, J. & Rowlands, M. (eds). 1977. *The evolution of social systems*. Duckworth, London.

Frigo, M. & Johnson, S. G. 1998. FFTW: An adaptive software achitecture for the FFT. *Proceedings of the International Conference on Acoustics, Speech and Signal Processing* 3: 1381-1384.

Gamble, C. 1986. *The Palaeolithic settlement of Europe.* Cambridge University Press, Cambridge.

Gamble, C. 1993. *Timewalkers: The Prehistory of Global Colonization.* Alan Sutton Publishing Ltd.

Gamble, C. 1998a. Handaxes and Palaeolithic Individuals. In N. Ashton, F. Healy & P. B. Pettitt (eds) *Stone Age Archaeology: essays in honour of John Wymer:* 105-109. Oxbow Books, Oxford.

Gamble, C. 1998b. Palaeolithic Society and the Release from Proximity: A Network Approach to Intimate Relationships. *World Archaeology* 29(3): 426-449.

Gamble, C. 1999. *The Palaeolithic Societies of Europe.* Cambridge University Press, Cambridge.

Gamble, C. 2004. Social Archaeology and the Unfinished Business of the Palaeolithic. In J. Cherry, C. Scarre & S. Shennan (eds) *Explaining Social Change: studies in honour of Colin Renfrew:* 17-26. McDonald Institute for Archaeological Research, Cambridge.

Gamble, C. 2007. *Origins and Revolutions: Human Identity in Earliest Prehistory.* Cambridge University Press, Cambridge.

Gamble, C. 2008. Breaking the Time Barrier. *Geoscientist* 18: 11-19.

Gamble, C. 2009. 150 Years of Cutting Edge Research. In R. T. Hosfield, F. Wenban-Smith & M. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research 1859-2009 (Special Volume 30 of Lithics: The Journal of the Lithic Studies Society):* 9-12. Lithic Studies Society, London.

Gamble, C. 2010. Technologies of Separation and the Evolution of Social Extension. In R. Dunbar, C. Gamble & J. A. J. Gowlett (eds) *Social Brain, Distributed Mind. Proceedings of the British Academy 158:* 17-42. Oxford University Press, Oxford.

Gamble, C. & Gaudzinski, S. 2005. Bones and powerful individuals: Faunal case studies from the Arctic and the European Middle Pleistocene. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts:* 154-175. Routledge, London.

Gamble, C. & Gittins, E. 2004. Social Archaeology and Origins Research: A Palaeolithic Perspective. In L. Meskell & R. W. Preucel (eds) *A Companion to Social Archaeology:* 96-118. Blackwell Publishing, Oxford.

Gamble, C. & Porr, M. 2005a. From empty spaces to lived lives: Exploring the individual in the Palaeolithic. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts:* 1-12. Routledge, London.

Gamble, C. & Porr, M. (eds). 2005b. *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Routledge, London.

Gamble, C. S. 1996a. Hominid behaviour in the MIddle Pleistocene: an English perspective. In C. S. Gamble & A. J. Lawson (eds) *The English Palaeolithic Reviewed:* 63-71. Trust for Wessex Archaeology, Wessex.

Gamble, C. S. 1996b. Making tracks: hominid networks and the evolution of the social landscape. In J. Steele & S. Shennan (eds) *The Archaeology of Human Ancestry: Power, Sex and Tradition:* 253-277. Routledge, London.

Gargett, R. H. 1989. Grave Shortcomings: the Evidence for Neanderthal Burial. *Current Anthropology* 30(2): 157-190.

Gargett, R. H. 1999. Middle Palaeolithic burial is not a dead issue: the view from Qafzeh, Saint-Césaire, Kebara, Amud, and Dederiyeh. *Journal of Human Evolution* 37: 27-90.

Giddens, A. 1979. *Central Problems in Social Theory: Action, structure and contradiciton in social analysis.* Macmillan Press, London.

Giddens, A. 1984. *The Constitution of Society: Outline of the Theory of Structuration.* Polity Press, Cambridge.

Goren-Inbar, N. 1992. The Acheulian site of Gesher Benot Ya'aqov: an African or Asian Entity. In T. Akawaza, K. Aoki & T. Kimura (eds) *The Evolution and Dispersal of Modern HUmans in Asia:* 67-82. Hokusen-Sha, Japan.

Goren-Inbar, N., Alperson, N., Kislev, M., Simchoni, O., Melamed, Y., Ben-Nun, A. & Werker, E. 2004. Evidence of Hominin Control of Fire at Gesher Benot Ya'aqov, Israel. *Science* 304: 725-727.

Goren-Inbar, N. & Sharon, G. 2006. Introduction. In N. Goren-Inbar & G. Sharon (eds) *Axe Age: Acheulian Toolmaking from Quarry to Discard:* 1-3. Equinox, London.

Gosden, C. 1994. *Social Being and Time.* Blackwell, Oxford.

Gosden, C. 1999. *Anthropology and Archaeology: a changing relationship.* Routledge, London.

Gowlett, J. A. J. 1984. Mental abilities of early man: a look at some hard evidence. In R. A. Foley (ed.) *Hominid Evolution and Community Ecology:* 167-192. Academic Press, London.

Gowlett, J. A. J. 1996. Mental abilities of early Homo: elements of constraint and choice in rule systems. In P. Mellars & K. R. Gibson (eds) *Modelling the Human Mind:* 191-215. McDonald Institute for Archaeological Research, Cambridge.

Gowlett, J. A. J. 1998. Unity and Diversity in the Early Stone Age. In N. Ashton, F. Healy & P. B. Pettitt (eds) *Stone Age Archaeology: essays in honour of John Wymer:* 59-66. Oxbow Books, Oxford.

Gowlett, J. A. J. 1999. Lower and Middle Pleistocene archaeology of the Baringo Basin. In P. Andrews & P. Banham (eds) *Late Cenozoic environments and hominid evolution: a tribute to Bill Bishop:* 123-141. Geographical Society, London.

Gowlett, J. A. J. 2005. Seeking the Palaeolithic Individual in East Africa and Europe During the Lower-Middle Pleistocene. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts:* 50-67. Routledge, London.

Gowlett, J. A. J. 2006a. The early settlement of northern Europe: fire history in the context of climate change and the social brain. *Comptes Rendus Palevol* 5: 299-310.

Gowlett, J. A. J. 2006b. The elements of design form in Acheulian bifaces: modes, modalities, rules and language. In N. Goren-Inbar & G. Sharon (eds) *Axe Age: Acheulian Toolmaking from Quarry to Discard:* 203-221. Equinox Publishing Limited, London.

Gowlett, J. A. J. 2009. Boucher de Perthes: Pioneer of Palaeolithic Prehistory. In R. T. Hosfield, F. Wenban-Smith & M. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research 1859-2009 (Special Volume 30 of Lithics: The Journal of the Lithic Studies Society):* 13-24. Lithic Studies Society, London.

Gowlett, J. A. J. 2010. Firing Up the Social Brain. In R. Dunbar, C. Gamble & J. A. J. Gowlett (eds) *Social Brain, Distributed Mind. Proceedings of the British Academy 158:* 341-366. Oxford University Press, Oxford.

Gowlett, J. A. J. & Hallos, J. 2000. Beeches Pit: Overview of the Archaeology. In S. G. Lewis, C. A. Whiteman & R. C. Preece (eds) *The Quaternary of Norfolk and Suffolk, QRA Field Guide:* 197-206. Quaternary Research Association, London.

Gowlett, J. A. J., Hallos, J., Hounsell, S., Brant, V. & Pumphrey, T. R. J. 2005. Beeches Pit - archaeology, assemblage dynamics and early fire history of a Middle Pleistocene site in East Anglia, UK. *Journal of Eurasian Prehistory* 3: 3-40.

Gowlett, J. A. J., Harris, J. W. K., Walton, D. & Wood, B. A. 1981. Early archaeological sites, hominid remains and traces of fire from Chesonwanja, Kenya. *Nature* 294: 125-129.

Grant, J. W. A., Chapman, C. A. & Richardson, K. S. 1992. Defended versus undefended home range size of carnivores, ungulates and primates. *Behavioral Ecology and Sociobiology* 31: 149-161.

Gravina, B. 2004. Agency, Technology, and the 'Muddle in the Middle': The Case of the Middle Palaeolithic. In A. Gardner (ed.) *Agency Uncovered: Archaeological perspectives on social agency, power and being human:* 65-78. UCL Press, London.

Grayson, D. K. 1984. Eoliths, Archaeological Ambiguity, and the Generation of 'Middle-Range' Research. In D. J. Meltzer, D. D. Fowler & J. A. Sabloff (eds) *American Archaeology: Past, Present and Future. A Celebration of the Society for American Archaeology:* 77-133. Smithsonian Institute Press, Washington D.C.

Grimm, L. 2000. Apprentice Flintknapping: Relating material culture and social practice in the Palaeolithic. In J. Sofaer Derevenski (ed.) *Children and Material Culture:* 53-71. Routledge, London.

Gunn, J. 1975. Idiosyncratic Behaviour in Chipping Style: Some Hypotheses and Preliminary Analysis. In E. Swanson (ed.) *Lithic Technology: making and using stone tools:* 35-61. Mouton Publishers, The Hague.

Gunn, J. 1977. Idiosyncratic Chipping Style as a Demographic Indicator: A Proposed Application to the South Hills Region of Idaho and Utah. In J. N. Hill & J. Gunn (eds) *The Individual in Prehistory: Studies of Variability in Style in Prehistoric Technology:* 167-204. Academic Press, London.

Hallos, J. 2005. "15 Minutes of Fame": Exploring the temporal dimension of Middle Palaeolithic lithic technology. *Journal of Human Evolution* 49: 155-179.

Hawkes, C. 1954. Archaeological Theory and Methof: Some Suggestions from the Old World. *American Anthropologist* 56(2): 155-168.

Hawkes, J. 1968. The Proper Study of Mankind. *Antiquity* 42: 255-262.

Henshilwood, C. & d'Errico, F. 2005. Being Modern in the Middle Stone Age: Individuals and innovation. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Routledge, London.

Hill, J. N. 1978. Individuals and Their Artifacts: An Experimental Study in Archaeology. *American Antiquity* 43(2): 245-257.

Hill, J. N. & Gunn, J. 1977. Introducing the Individual in Prehistory. In J. N. Hill & J. Gunn (eds) *The Individual in Prehistory: Studies of Variability and Style in Prehistoric Technology:* 1-12. Academic Press, New York.

Hillson, S. W., Parfitt, S. A., Bello, S. M., Roberts, M. B. & Stringer, C. B. 2010. Two hominin incisor teeth from the Middle Pleistocene site of Boxgrove, West Sussex, England. *Journal of Human Evolution* 59(493-503).

Hodder, I. 1982. *Symbols in Action.* Cambridge University Press, Cambridge.

Hodder, I. 1990. *The Domestication of Europe.* Blackwell, Oxford.

Hodder, I. 1992. *Theory and Practice in Archaeology.* Routledge, London.

Hodder, I. 2000. Agency and individuals in long-term processes. In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 21-33. Routledge, London.

Hodder, I. & Orton, C. 1976. *Spatial Analysis in Archaeology.* Cambridge University Press, Cambridge.

Holloway, R. L. 1969. Culture: A Human Domain. *Current Anthropology* 10(4): 395-412.

Holmes, J. A., Atkinson, T., Fiona Darbyshire, D. P., Horne, D. J., Joordens, J., Roberts, M., Sinka, K. J. & Whittaker, J. E. 2010. Middle Pleistocene climate and hydrological environment at the Boxgrove hominin site (West Sussex, UK) from ostracod records. *Quaternary Science Reviews* 29: 1515-1527.

Hopkinson, T. & White, M. J. 2005. The Acheulean and the handaxe: Structure and agency in the Palaeolithic. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Routledge, London.

Hosfield, R. T. 2011. The Birtish Lower Palaeolithic of the early Middle Pleistocene. *Quaternary Science Reviews* 30: 1486-1510.

Hosfield, R. T. & Chambers, J. 2009. Genuine Diversity? The Broom Biface Assemblage. *Proceedings of the Prehistoric Society* 75: 65-100.

Ingold, T. 1993. Tool-use, sociality and intellegence. In K. R. Gibson & T. Ingold (eds) *Tools, Language and Cognition in Human Evolution:* 429-445. Cambridge University Press, Cambridge.

Ingold, T. 2000. *The Perception of the Environment: Essays in Livelyhood, Dwelling and Skill.* Routledge, London.

Isaac, G. L. 1972. Early phases of human behaviour: models in Lower Palaeolithic archaeology. In D. L. Clark (ed.) *Models in Archaeology:* 167-199. Methuen, London.

Isaac, G. L. 1972. Chronology and tempo of cultural change during the Pleistocene. In W. W. Bishop & J. Miller (eds) *Calibration in Hominid Evolution:* 381-430. Scottish Academic Press, Edinburgh.

Isaac, G. L. 1976. Stages of Cultural Elaboration in the Pleistocene: Possible Archaeolgical Indicators of the Development of Language Capabilities. In S. R. Harnad, H. D. Stekelis & J. Lancaster (eds) *Origins and Evolution of Language and Speech:* 275-288. New York Academy of Science, New York.

Isaac, G. L. 1977. *Olorgesailie: Archaeological Studies of a Middle Pleistocene Lake Basin in Kenya.* University of Chicago Press, Chicago & London.

Jeffrey, R. W. 1957. Slindon Hand-Axe. *Sussex Notes and Queries* 14: 242.

Johnson, M. 1999. *Archaeological Theory: An Introduction.* Blackwell, Oxford.

Jones, P. R. 1979. Effects of Raw Materials on Biface Manufacture. *Science* 204: 835-836.

Jones, S. 1997. *The Archaeology of Ethnicity: Constructing identities in the past and present.* Routledge, London.

Kahlke, R.-D., Maul, L. C., Meyrick, R. A., Stebich, M. & Gasselt, T. 2002. The Quaternary sequence from the late Middle to Upper Pleistocene site of Weimar-Ehringsdorf. In R. A. Meyrick & D. C. Schreve (eds) *The Quaternary of Central Germany (Thuringia and Surroundings): Field Guide:* 163-177. Quaternary Reserach Association, London.

Karlin, C., Ploux, S., Bodu, P. & Pigeot, N. 1993. Some socio-economic aspects of the knapping process among groups of hunter-gatherers in the Paris Basin area. In A. Berthelet & J. Chavaillon (eds) *The Use of Tools by Human and Non-human Primates:* 318-337. Oxford University Press, Oxford.

Keeley, L. H. 1980. *Experimental Determination of Stone Tool Uses.* The University of Chicago Press, Chicago.

Klein, R. G. 1999. *The Human Career (2nd Edition).* The University of Chicago Press, Chicago.

Kleindienst, M. R. 1962. Components of the East African Acheulian assemblage: an analytical approach. In G. Mortelmans (ed.) *Actes du IVème Congrès Panafricain de Préhistoire et de l'Etude du Quaternaire (Vol. 40):* 81-105. Musée Royal de l'Afrique Centrale, Tervuren.

Knapp, A. B. & van Dommelen, P. 2008. Past practices: Rethinking individuals and agents in archaeology. *Cambridge Archaeological Journal* 18(1): 15-34.

Kohn, M. & Mithen, S. 1999. Handaxes: products of sexual selection? *Antiquity* 73: 518-526.

Lamdin-Whymark, H. 2009. Sir John Evans: Experimental Flint Knapping and the Origins of Lithic Research. In R. T. Hosfield, F. Wenban-Smith & M. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research, 1859-2009 (Special Volume 30 of Lithics: The Journals of the Lithic Studies Society:* 45-52. Lithic Studies Society, London.

Layard, N. F. 1902. Palaeolithic Implements in Ipswich. *Nature* 66: 77.

Layard, N. F. 1903. A Recent Discovery of Palaeolithic Implements in Ipswich. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 33: 41-43.

Layard, N. F. 1904. Further excavations on a Palaeolithic site in Ipswich. *Journal of the Anthropological Institute* 34: 306-310.

Layard, N. F. 1906a. A Winter's Work on the Ipswich Palaeolithic Site. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 36: 233-236.

Layard, N. F. 1906b. Account of a Palaeolithic site in Ipswich. *Proceedings and Communications of the Cambridge Antiquarian Society* 11: 493-502.

Lemonnier, P. 1992. *Elements for an Anthropology of Techology.* Museum of Anthropology, University of Michigan, Michigan.

Levent Atici, A. 2006. Middle-Range Theory in Palaeolithic Archaeology: The Past and Present. *Journal of Taphonomy* 4(1): 29-45.

Lieberman, P. 1989. The origins of some aspects of human language and cognition. In P. Mellars & C. B. Stringer (eds) *The Human Revolution: behavioural and biological perspectives on the evolution of modern humans:* 391-414. Princeton University Press, Princeton.

Lieberman, P. 1992. On Neanderthal Speech and Neanderthal Extinction. *Current Anthropology* 33(4): 409-410.

Lieberman, P. 2007. The Evolution of Human Speech: Its Anatomical and Neural Bases. *Current Anthropology* 48(1): 39-66.

Loveday, J. 1962. Plateau deposits of the southern Chiltern Hills. *Proceedings of the Geologists' Association* 73: 83-102.

Lycett, S. J. 2008. Acheulean variation and selection: does handaxe symmetry fit neutral expectations? *Journal of Archaeological Science* 35: 2640-2648.

Lycett, S. J. 2009. Understanding Ancient Hominin Dispersals Using Artefactual Data: A Phylogenetic Analysis of Acheulean Handaxes. *Plos One* 4(10): 1-6.

Lycett, S. J. & Gowlett, J. A. J. 2008. On questions surrounding the Acheulean "tradition". *World Archaeology* 40(3): 295-315.

Machin, A. J., Hosfield, R. T. & Mithen, S. 2005. Testing the functional utility of handaxe symmetry: fallow deer butchery with replica handaxes. *Lithics* 26: 23-37.

Machin, A. J., Hosfield, R. T. & Mithen, S. J. 2007. Why are some handaxes symmetrical? Testing the influence of handaxe morphology on butchery effectiveness. *Journal of Archaeological Science* 34: 883-893.

MacPhail, R. I. 1999. 2.6 Sediment micromorphology. In M. B. Roberts & S. A. Parfitt (eds) *Boxgrove: a middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex:* 119-149. English Heritage, London.

Mania, D. 1991. The zonal division of the Lower Palaeolithic open-air site at Bilzingsleben. *Anthropologie* 29: 17-24.

Mania, D. & Mania, U. 2005. The natural and socio-cultural environment of *Homo erectus* at Bilzingsleben, Germany. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artefacts:* 98-114. Routledge, London.

Marshack, A. 1997. The Berekhat Ram Figurine: A Late Acheulian Carving from the Middle East. *Antiquity* 71: 327-337.

Martínez, I., Rosa, M., Arsuaga, J. L., Jarabo, P., Quam, R., Lorenzo, C., Gracia, A., Carretero, J. M., Bermúdez de Castro, J. M. & Carbonell, E. 2004. Auditory capacities in Middle Pleistocene humans from the Sierra de Atapuerca in Spain. *Proceedings of the National Academy of Sciences of the United States of America* 101: 9976-9981.

MathWorks, n.d. MATLAB R2012a Documentation - Fast Fourier transform.

Mauss, M. 1950. *Sociologie et anthropologie.* Presses Universitaires de France, Paris.

McBurney, C. B. 1950. The geographical study of the older Palaeolithic stages in Europe. *Proceedings of the Prehistoric Society* 16: 163-183.

McCrone 2000. Fired Up. *New Scientist* 166(2239): 30-35.

McCullagh, M. J. & Davis, J. C. 1972. Optical Analysis of Two-Dimensional Patterns. *Annals of the Association of American Geographers* 62(4): 561-577.

McGhee, R. 1980. Individual Stylistic Variability in Independence I Stone Tool Assemblages from Port Refuge, N.W.T. *Arctic* 33(3): 443-453.

McNabb, J. 2007. *The British Palaeolithic: Stones in Contention.* Routledge, London.

McNabb, J. & Ashton, N. 1992. The cutting edge: bifaces in the Clactonian. *Lithics* 13: 4-10.

McNabb, J. & Ashton, N. 1996. More from the cutting edge: further discoveries of Clactonian bifaces. *Antiquity* 70: 428-436.

McNabb, J., Binyon, F. & Hazelwood, L. 2004. The Large Cutting Tools from the South African Acheulean and the Question of Social Traditions. *Current Anthropology* 45(5): 653-677.

McPherron, S. 1994. *A Reduction Model for Variability in Acheulian Biface Morphology*, Unpublished PhD Thesis, University of Pennsylvania.

McPherron, S. 1995. A re-examination of the British biface data. *Lithics* 16: 47-63.

McPherron, S. 2000. Handaxes as a Measure of the Mental Capabilities of Early Hominids. *Journal of Archaeological Science* 27: 655-663.

McPherron, S. 2006. What typology can tell us about Acheulian handaxe production. In N. Goren-Inbar & G. Sharon (eds) *Axe Age: Acheulian Toolmaking from Quarry to Discard:* 267-285. Equinox Publishing Ltd., London.

Millson, D. C. E. (ed.) 2010. *Experimentation and Interpretation: The Use of Experimental Archaeology in the Study of the Past*. Oxbow Books, Oxford.

Mithen, S. 1990. *Thoughtful foragers: a study of prehistoric decision making.* Cambridge University Press, Cambridge.

Mithen, S. 1991. Ecological Interpretations of Palaeolithic Art. *Proceedings of the Prehistoric Society* 57: 103-114.

Mithen, S. 1993. Individuals, Groups and the Palaeolithic Record: A Reply to Clark. *Proceedings of the Prehistoric Society* 59: 393-398.

Mithen, S. 1994. Technology and Society during the Middle Pleistocene: Hominid Group Size, Social Learning and Industrial Variability. *Cambridge Archaeological Journal* 4(1): 3-32.

Mithen, S. 1996a. Social Learning and Cultural Tradition: interpreting Early Palaeolithic technology. In J. Steele & S. Shennan (eds) *The Archaeology of Human Ancestry: Power, Sex and Tradition:* 207-229. Routledge, London.

Mithen, S. 1996b. *The Prehistory of the Mind.* Thames and Hudson, London.

Mithen, S. 1999. Imitation and cultural change: a view from the Stone Age, with specific reference to the manufacture of handaxes. In H. O. Box & K. R. Gibson (eds) *Mammalian Social Learning: Comparative and Ecological Perspectives:* 389-399. Cambridge University Press, Cambridge.

Mithen, S. & Machin, A. J. 2004. Comment on McNabb *et al*. The Large Cutting Tools from the South African Acheulean and the Question of Social Traditions. *Current Anthropology* 45(5): 668-669.

Moncel, M.-H. 2010. Oldest human expansions in Eurasia: favouring and limiting factors. *Quaternary International* 223/224: 1-9.

Moore, H. L. 2000. Ethics and Ontology: Why agents and agency matter. In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 259-263. Routledge, London.

Newcomer, M. H. 1971. Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3(1): 85-104.

Nowell, A. & White, M. J. 2010. Growing Up in the Middle Pleistocene: life history strategies and their relationship to Acheulian industries. In A. Nowell & I. Davidson (eds) *Stone Tools and the Evolution of Human Cognition:* 67-81. University Press of Colorado, Boulder.

O'Conner, A. 2007. *Finding Time for the Old Stone Age: A history of Palaeolithic Archaeology and Quaternary Geology in Britain, 1860-1960.* Oxford University Press, Oxford.

Oakley, K. P. 1973. Fossil shell observed by Acheulian man. *Antiquity* 47: 59-60.

Oakley, K. P. 1981. The emergence of higher thought 3.0-0.2 Ma BP. *Philosophical Transactions of the Royal Society of London B* 292: 205-211.

Oxnard, C. 1973. *Form and Pattern in Human Evolution: Some Mathematical, Physical, and Engineering Approaches.* Chicago University Press, Chicago.

Parfitt, S. A., Ashton, N., Lewis, S. G., Abel, R. L., Coope, R., Field, M., Gale, R., Hoare, P. G., Larkin, N. R., Lewis, M. D., Kaloukovski, V., Maher, B. A., Peglar, S. M., Preece, R. C., Whittaker, J. E. & Stringer, C. B. 2010. Early Pleistocene human occupation at the edge of the boreal zone in northwest Europe. *Nature* 466: 229-233.

Parfitt, S. A., Barendregt, R. W., Breda, M., Candy, I., Collins, M. J., Coope, G. R., Durbridge, P., Field, M., Lee, J. R., Lister, A. M., Mutch, R., Penkman, K. E. H., Preece, R. C., Rose, J., Stringer, C. B., Symmons, R., Whittaker, J. E., Wymer, J. J. & Stuart, A. J. 2005. The earliest record of human activity in northern Europe. *Nature* 438: 1008-1012.

Pelegrin, J. 1993. A framework for analysing prehistoric stone tool manufacture and a tentative application to some early stone industries. In A. Berthelet & J. Chavaillon (eds) *The Use of Tools by Human and Non-human Primates:* 302-314. Oxford University Press, Oxford.

Pettitt, P. B. 2010. *The Palaeolithic Origins of Human Burial.* Routledge, London.

Pettitt, P. B. & White, M. J. 2012. *The British Palaeolithic: Human Societies at the Edge of the Pleistocene World.* Routledge, London.

Pfaffenberger, B. 1988. Fetishised Objects and Humanised Nature: Towards an Anthropology of Technology. *Man* 23(2): 236-252.

Pigeot, N. 1990. Technical and Social Actors: Flint knapping specialists and apprentices at Magdalenian Etiolles. *Archaeological Review from Cambridge* 9(1): 126-141.

Pitts, M. & Roberts, M. 1997. *Fairweather Eden: Life in Britain half a million years ago as revealed by the excavation at Boxgrove.* Century, London.

Pope, M. 2002. *The significance of biface rich assemblages: an examination of behavioural controls on lithic assemblage formation in the Lower Palaeolithic*, Unpublished PhD Thesis, Department of Archaeology, University of Southampton.

Pope, M. 2004. Behavioural implications of biface discard: assemblage variability and land-use at the Middle Pleistocene site of Boxgrove. In E. A. Walker, F. Wenban-Smith & F. Healy (eds) *Lithics in action : papers from the conference 'Lithic Studies in the Year 2000':* 38-47. Oxbow Books, Oxford.

Pope, M. & Roberts, M. 2005. Observations on the relationship between Palaeolithic individuals and artefact scatters at the Middle Pleistocene site of Boxgrove, UK. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts:* 81-97. Routledge, London.

Pope, M. & Roberts, M. 2009. "Clenching Authority": Joseph Prestwich and the Proofs of the Antiquity of Man. In R. T. Hosfield, F. Wenban-Smith & M. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research, 1859-2009 (Special Volume 30 of Lithics: The Journals of the Lithic Studies Society:* 35-44. Lithic Studies Society, London.

Pope, M., Russel, K. & Watson, K. 2006. Biface Form and Structured Behaviour in the Acheulean. *Lithics* 27: 44-57.

Pope, M. I. 2001. New Investigations at Slindon Bottom Palaelithic Site, West Sussex: An Interim Report. *Lithics* 2001: 3-10.

Porr, M. 2000. Signs of the Times: A Different Approach towards the Origins of Lower Palaeolithic Handaxes. *Archaeological Review from Cambridge* 17(1): 19-32.

Porr, M. 2005. The making of the biface and the making of the individual. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts:* 68-80. Routledge, London.

Preece, R. C., Bridgland, D. R., Lewis, S. G., Parfitt, S. A. & Griffiths, H. I. 2000. Beeches Pit, West Stow, Suffolk (TL 798719). In S. G. Lewis, C. A. Whiteman & R. C. Preece (eds) *The Quaternary of Norfolk and Suffolk, QRA Field Guide:* 185-196. Quaternary Research Association, London.

Preece, R. C., Gowlett, J. A. J., Parfitt, S. A., Bridgland, D. R. & Lewis, S. G. 2006. Humans in the Hoxnian: habitat, context, and fire use at Beeches Pit, West Stow, Suffolk, UK. *Journal of Quaternary Science* 21: 485-496.

Preece, R. C., Lewis, S. G., Wymer, J., Bridgland, D. R. & Parfitt, S. A. 1991. Beeches Pit, West Stow, Suffolk (TL 798719). In S. G. Lewis, C. A. Whiteman & D. R. Bridgland (eds) *Central East Anglia and the Fen Basin, QRA Field Guide:* 94-104. Quaternary Research Association, London.

Preston, F. W., Green, D. W. & Davis, J. C. 1969. Numerical characterization of reservoir rock pore structure. *Second Annual Report to the American Petroleum Institute* Research Report 103: 1-84.

Raab, L. M. & Goodyear, A. C. 1984. Middle-Range Theory in Archaeology: A Critical Review of Origins and Applications. *American Antiquity* 49(2): 255-268.

Redman, C. 1977. The 'Analytical Individual' and Prehistoric Style Variability. In J. N. Hill & J. Gunn (eds) *The Individual in Prehistory: Studies of Variability in Style in Prehistoric Technologies:* 41-53. Academic Press, New York.

Redman, C., Berman, M. J., Curtin, E. V., Langhorne, W. T., Versaggi, N. M. & Wanser, J. C. (eds). 1978. *Social Archaeology*. Academic Press, New York.

Renfrew, C. 1973. *Before Civilisation.* Jonathon Cape, London.

Renfrew, C. & Shennan, S. J. 1982. *Rancking, resource and exchange.* Cambridge University Press, Cambridge.

Roberts, M. 1986. Excavation of the Lower Palaeolithic Site at Amey's Eartham Pit, Boxgrove, West Sussex: A Preliminary Report. *Proceedings of the Prehistoric Society* 52: 215-245.

Roberts, M. 1996. The age and significance of the Middle Pleistocene sediments at Boxgrove, West Sussex, UK and their associated archaeology. In K. W. Beinhauer, R. Kraatz & G. A. Wagner (eds) *Neue Funde und Forschungen zur frühen Menschheitsgeschichte Eurasiens mit einem Ausblick auf Afrika:* 63-78. Sigmaringen.

Roberts, M., Gamble, C. & Bridgland, D. R. 1995. The earliest occupation of Europe: the British Isles. In W. Roebroeks & T. van Kolfschoten (eds) *The earliest occupation of Europe:* 165-191. University of Leiden and European Science Foundation, Leiden.

Roberts, M. & Pitts, M. 1997. *Fairweather Eden: Life in Britian half a million years ago as revealed by the excavations at Boxgrove.* Century, London.

Roberts, M. & Pope, M. I. 2009. The archaeological and sedimentary records from Boxgrove and Slindon. In R. M. Briant, M. R. Bates, R. T. Hosfield & F. Wenban-Smith (eds) *The Quaternary of the Solent Basin and West Sussex Rasied Beaches, ORA Field Guide:* 96-122. Quaternary Research Association, London.

Roberts, M., Stringer, C. B. & Parfitt, S. A. 1994. A hominid tibia from Middle Pleistocene sediments at Boxgrove, UK. *Nature* 369: 311-313.

Roberts, M. B. & Parfitt, S. A. 1999. *Boxgrove: a middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex.* English Heritage, London.

Roe, D. 1964. The British Lower and Middle Palaeolithic: some problems, methods of study, and preliminary results. *Proceedings of the Prehistoric Society* 30: 345-367.

Roe, D. 1968. British Lower and Middle Palaeolithic Handaxe Groups. *Proceedings of the Prehistoric Society* 34: 1-82.

Roe, D. 1980. Introduction: Precise moments in remote time. *World Archaeology* 12(2): 107-108.

Roe, D. 1981. *The Lower and Middle Palaeolithic Periods in Britain.* Routledge and Kegan Paul, London.

Roe, D. 2009. Worthington George Smith (1835-1917). In R. T. Hosfield, F. Wenban-Smith & M. I. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research, 1859-2009 (Special Volume 30 of Lithics: The Journal of the Lithic Studies Society:* 85-95. Lithic Studies Society, London.

Roebroeks, W. 2001. Hominid behaviour and the earliest occuption of Europe: an exploration. *Journal of Human Evolution* 41: 437-461.

Roebroeks, W. 2006. The human colonisation of Europe: where are we? *Journal of Quaternary Science* 21: 425-435.

Roebroeks, W. & van Kolfschoten, T. 1994. The earliest occupation of Europe: a short chronology. *Antiquity* 68: 489-503.

Roebroeks, W. & van Kolfschoten, T. 1995a. The earliest occupation of Europe: a reappraisal of artefactual and chronological evidence. In W. Roebroeks & T. van Kolfschoten (eds) *The Earliest Occupation of Europe: Proceedings of the European Science Foundation Workshop at Tautavel (France), 1993 (Analecta Praehistorica Leidensia 27):* 297-315. University of Leiden Press, Leiden.

Roebroeks, W. & van Kolfschoten, T. (eds). 1995b. *The Earliest Occupation of Europe: Proceedings of the European Science Foundation Workshop at Tautavel (France), 1993 (Analecta Praehistorica Leidensia 27).* University of Leiden Press, Leiden.

Roebroeks, W. & Villa, P. 2011. On the earliest evidence for habitual use of fire in Europe. *Proceedings of the National Academy of Sciences of the United States of America* 108(13): 5209-5214.

Rolland, N. & Dibble, H. L. 1990. A New Synthesis of Middle Paleolithic Variability. *American Antiquity* 55: 480-499.

Rossano, M. J. 2009. The archaeology of consciousness. In S. A. de Beaune, F. L. Coolidge & T. Wynn (eds) *Cognitive Archaeology and Human Evolution:* 25-35. Cambridge University Press, Cambridge.

Rowley-Conwy, P. 2001. Science, theory and archaeology in Britain: a minimalist view of the debate. *Archaeologia Polona* 39: 17-36.

Sabloff, J. A. 2005. Processual Archaeology. In C. Renfrew & P. G. Bahn (eds) *Archaeology: The Key Concepts:* 212-219. Routledge, London.

Sackett, J. R. 1977. The meaning of style in archaeology: a general model. *American Antiquity* 42(3): 369-380.

Sackett, J. R. 1981. From de Mortillet to Bordes: a century of French Palaeolithic research. In G. Daniel (ed.) *Towards a History of Archaeology: Being the papers read at the first Conference on the History of Archaeology in Aarhus, 29 August - 2 September 1978:* 85-99. Thames and Hudson, London.

Sackett, J. R. 1982. Approaches to style in lithic archaeology. *Journal of Anthropological Archaeology* 1: 59-112.

Sackett, J. R. 1985. Style and Ethnicity in the Kalahari: a reply to Weissner. *American Antiquity* 50: 154-160.

Sampson, C. G. 1978a. Excavation and Stratigraphy of the Rackley Site. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 29-38. Department of Anthropology, Southern Methodist University, Dallas.

Sampson, C. G. 1978b. Introduction. In C. G. Sampson (ed.) *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England:* 3-15. Department of Anthropology, Southern Methodist University, Dallas.

Sampson, C. G. (ed.) 1978c. *Palaeoecology and Archaeology of an Acheulian Site at Caddington, England*. Department of Anthropology, Southern Methodist University, Dallas.

Sassaman, K. E. 2000. Agents of change in hunter-gatherer technology. In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 148-168. Routledge, London.

Schick, K. D. 1992. Geoarchaeological analysis of an acheulean site at Kalambo Falls, Zambia. *Geoarchaeology* 7: 1-26.

Schick, K. D. & Toth, N. 1993. *Making Silent Stones Speak: Human Evolution and the Dawn of Technology.* Weidenfeld and Nicolson, London.

Schlanger, N. 1990. Techniques as Human Action - Two Perspectives. *Archaeological Review from Cambridge* 9(1): 18-26.

Schlanger, N. 1994. Mindful technology: unleashing the *châine opératoire* for an archaeology of the mind. In C. Renfrew & E. Zubrow (eds) *The ancient mind: elements of cognitive archaeology:* 143-151. Cambridge University Press, Cambridge.

Schlanger, N. 1996. Understanding Levallois: Lithic Technology and Cognitive Archaeology. *Cambridge Archaeological Journal* 6(2): 231-254.

Schnapp, A. 1999. *The Discovery of the Past.* British Museum Press, London.

Shanks, M. & Tilley, C. 1987. *Social Theory and Archaeology.* Polity Press, Cambridge.

Sharon, G. 2007. *Acheulian Large Flake Industries: Technology, Chronology, and Significance.* BAR International Series 1701.

Sharpe, K. & van Gelder, L. 2006. Evidence for cave markings by Palaeolithic children. *Antiquity* 80(4): 937-947.

Shaw, A. D. & White, M. J. 2003. Another look at the Cuxton handaxes. *Proceedings of the Prehistoric Society* 69: 305-314.

Shennan, S. 2001. Demography and Cultural Innovation: A Model and Its Implications for the Emergence of Modern Hurman Culture. *Cambridge Archaeological Journal* 11: 5-16.

Shennan, S. & Steele, J. 1999. Cultural learning in hominids: a behavioural ecological approach. In H. O. Box & K. R. Gibson (eds) *Mammalian Social Learning: Comparative and Ecological Perspectives:* 367-388. Cambridge University Press, Cambridge.

Sinclair, A. 2000. Constellations of Knowledge: Human agency and material affordances in lithic technology. In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 196-212. Routledge, London.

Singer, R., Gladfelter, B. G. & Wymer, J. (eds). 1993. *The Lower Palaeolithic site at Hoxne, England*. Chicago University Press, Chicago.

Smith, R. A. 1921a. *A Guide to the Antiquities of the British Museum in the Department of British and Mediaeval Antiquities.* British Museum, London.

Smith, R. A. 1921b. Implements from Plateau Brick-Earth at Ipswich. *Proceedings of the Geologists' Association of London* 32: 1-16.

Smith, W. G. 1879. On Palaeolithic Implements from the Valley of the Lea. *Journal of the Anthropological Institute* 8: 275-278.

Smith, W. G. 1883a. Palaeolithic Implements of North-east London. *Nature* 27: 270-274.

Smith, W. G. 1883b. Primeval man in the valley of the Lea. *Transactions of the Essex Field Club* 3: 102-147.

Smith, W. G. 1884. On a Palaeolithic floor at northest London. *Journal of the Anthropological Institute* 13: 357-384.

Smith, W. G. 1887. Primeval man in the valley of the Lea. *Essex Naturalist* 1: 36-38, 83-91, 125-137.

Smith, W. G. 1889. Palaeolithic Implements from the Hills near Dunstable. *Nature* 40: 151.

Smith, W. G. 1894. *Man the Primeval Savage: His Haunts and Relics from the Hilltops of Bedfordshire to Blackwall.* Edward Stanford, London.

Smith, W. G. 1904a. *Dunstable: it's history and surroundings.* Homeland Association, London.

Smith, W. G. 1904b. Early Man. In H. A. Doubleday & W. Page (eds) *The Victoria History of the Counties of England. A History of Bedfordshire: Volume One*. Archibald Constable and Company, Westminister.

Smith, W. G. 1916. Notes on the Palaeolithic Floor near Caddington. *Archaeologia* 67: 49-74.

Smith, W. G. n.d. *List of Palaeolithic implements*, Unpublished manuscript held in the archives of Luton Museum.

Sparks, B. M., West, R. G., Williams, R. B. G. & Ransom, M. 1969. Hoxnian interglacial deposits near Hatfield, Herts. *Proceedings of the Geologists' Association of London* (80): 243-267.

Speth, J. D. 1972. Mechanical Basis of Percussion Flaking. *American Antiquity* 37(1): 34-60.

Spurrell, F. C. J. 1880a. On Implements and Chips from the Floor of a Palaeolithic Workshop. *The Archaeological Journal* 37: 292-299.

Spurrell, F. C. J. 1880b. On the Discovery of the Place where Palaeolithic Implements were made at Crayford. *Quarterly Journal of the Geological Society of London* 114: 544-549.

Stapert, D. 2007. Youngsters Knapping Flint Near The Campfire: An alternative view of Site K at Maastricht-Belvédère (The Netherlands). *Archäologisches Korrespondenzblatt* 37: 19-35.

Steele, J. 1996. On Predicting Hominid Group Sizes. In J. Steele & S. Shennan (eds) *The Archaeology of Human Ancestry: Power, Sex and Tradition:* 230-252. Routledge, London.

Stern, N. 1993. The Structure of the Lower Pleistocene Archaeological Record: A Case study from the Koobi Fora Formation. *Current Anthropology* 34(3): 201-225.

Stern, N. 1994. The implications of time-averaging for reconstructing the land-use patterns of early tool-using hominids. *Journal of Human Evolution* 27: 89-105.

Stout, D. 2005. The social and cultural context of stone knapping skill acquisition. In V. Roux & B. Bril (eds) *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour:* 331-340. McDonald Institute for Archaeological Reseach, Cambridge.

Stringer, C. B. & Gamble, C. 1998. *In Search of the Neanderthals: Solving the Puzzle of Human Origins.* Thames and Hudson.

Stringer, C. B. & Hublin, J.-J. 1999. New age estimates for the Swanscombe hominid, and their significance for human evolution. *Journal of Human Evolution* 37: 873-877.

Stuart, A. J. & Lister, A. M. 2001. The mammalian faunas of Pakefield/Kessingland and Corton, Suffolk, UK: evidence for a new temporate episode in the British early Middle Pleistocene. *Quaternary Science Reviews* 20: 1677-1692.

Taylor, N., 2011. Characterisation of use-wear damage to bifacial stone tools: experimental results and archaeological applications, in *Unravelling the Palaeolithic: 10 years of research at the Center for the Archaeology of Human Origins* CAHO, University of Southampton, UK.

Theime, H. 2005. The Lower Palaeolithic art of hunting: the case of Schöningen 13 II-4, Lower Saxony, Germany. In C. Gamble & M. Porr (eds) *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artefacts:* 115-132. Routledge, London.

Thery-Parisot, I. 2002. Fuel management (bone and wood) during the lower aurignacian in the pataud rock shelter (lower palaeolithic, Les Eyrzies de Tayac, Dordogne, France). Contribution of experimentation. *Journal of Archaeological Science* 29: 1415-1421.

Thomas, J. 1991. *Rethinking the Neolithic.* Cambridge University Press, Cambridge.

Thomas, J. 2004. *Archaeology and Modernity.* Routledge, London.

Tomka, S. A. 1989. Differentiating Lithic Reduction Techniques: An Experimental Approach. In D. S. Amick & R. P. Mauldin (eds) *Experiments in Lithic Technology:* 137-161. B.A.R. International Series S528.

Trigger, B. G. 2006. *A History of Archaeological Thought.* Cambridge University Press, Cambridge.

Turner, C. 1970. The Middle Pleistocene deposits at Marks Tey, Essex. *Philosophical Transactions of the Royal Society of London B* 257: 373-440.

Valoch, K. 1987. The Early Palaeolithic Site Stránská Skála I near Brno (Czechoslovakia). *Anthropologie* 25: 125-142.

Van Peer, P. 2007. Refitting of Lithic Reduction Sequences, Formal Classification Systems, and Middle Palaeolithic Individuals at Work. In U. Schurmans & M. De Bie (eds) *Fitting Rocks: Lithic Refitting Examined:* 91-103. B.A.R. International Series S1596.

Vanhaeren, M. & d'Errico, F. 2005. Grave goods from the Saint-Germain-la-Rivière burial: Evidence for social inequality in the Upper Palaeolithic. *Journal of Anthropological Archaeology* 24: 117-134.

Vèrtes, L. & Dobosi, V. T. 1990. Fireplaces of the Settlement. In M. Kretzoi & V. T. Dobosi (eds) *Vèrtesszöllös - Man, Site and Culture:* 519-521. Akadémiai Kiado, Budpest.

Wadley, L. 2001. What is Cultural Modernity? A General View and a South African Perspective from Rose Cottage Cave. *Cambridge Archaeological Journal* 11(2): 201-221.

Walker, E. A. 2009. Discoveries in Devon: The works of Father John MacEnery and William Pengelly. In R. T. Hosfield, F. Wenban-Smith & M. Pope (eds) *Great Prehistorians: 150 Years of Palaeolithic Research 1859-2009 (Special Volume 30 of Lithics: The Journal of the Lithic Studies Society):* 25-33. Lithic Studies Society, London.

Warren, S. H. 1923. Sub-soil pressure flaking. *Proceedings of the Geologists' Association of London* 34: 153-175.

Wenban-Smith, F. 1999. 6.4 Knapping Technology. In M. Roberts & S. A. Parfitt (eds) *Boxgrove: a middle Pleistocene hominid site at Eartham Quarry, Boxgrove, West Sussex:* 384-395. English Heritage, London.

West, R. G. 1956. The Quaternary deposits at Hoxne, Suffolk. *Philosophical Transactions of the Royal Society of London B* 239: 265-356.

Westaway, R. in press. A re-evaluation of the timing of the earliest reported human occupation of Britain: The age of the sediments at Happisburgh, eastern England. *Proceedings of the Geologists' Association*.

White, M. J. 1995. Raw materials and biface variability in southern Britain, a preliminary examination. *Lithics* 15: 1-20.

White, M. J. 1997. The earlier Palaeolithic occupation of the Chilterns (southern England): re-assessing the sites of Worthington G. Smith. *Antiquity* 71: 912-931.

White, M. J. 1998a. On the Significance of Acheulean Biface Variability in Southern Britain. *Proceedings of the Prehistoric Society* 64: 15-44.

White, M. J. 1998b. Twisted Ovate Bifaces in the British Lower Palaeolithic: Some Observations and Implications. In N. Ashton, F. Healy & P. B. Pettitt (eds) *Stone Age Archaeology: essays in honour of John Wymer:* 98-104. Oxbow Books, Oxford.

White, M. J. 2000. The Clactonian Question: On the Interpretation of Core-and-Flake Assemblages in the British Lower Palaeolithic. *Journal of World Prehistory* 14(1): 1-63.

White, M. J. 2006a. Axeing cleavers: reflections on broad-tipped large cutting tools in the British earlier Paleolithic. In N. Goren-Inbar & G. Sharon (eds) *Axe Age: Acheulian Toolmaking from Quarry to Discard:* 365-386. Equinox Publishing Ltd., London.

White, M. J. 2006b. Things to do in Doggerland when you're dead: surviving OIS3 at the northwestern-most fringe of Middle Palaeolithic Europe. *World Archaeology* 38(4): 547-575.

White, M. J. 2008. Origins and Revolutions: Human Identity in Earliest Prehistory. *American Journal of Archaeology* 112(2): 355.

White, M. J. in press. 'Dancing to the Rhythms of the Biotidal Zone': Settlement History and Culture History in Middle Pleistocene Europe.

White, M. J. & Ashton, N. 2003. Lower Palaeolithic Core Technology and the Origins of the Levallois Method in North-Western Europe. *Current Anthropology* 44(4): 598-609.

White, M. J. & Jacobi, R. M. 2002. Two Sides to Every Story: *Bout Coupé* Handaxes Revisited. *Oxford Journal of Archaeology* 21(2): 109-133.

White, M. J., Lewis, S. G. & McNabb, J. 1999. Excavations at the Lower Palaeolithic site of Whipsnade, Bedfordshire 1992-4. *Proceedings of the Geologists' Association* 110: 241-255.

White, M. J. & Pettitt, P. B. 2011. The British Late Middle Palaeolithic: an interpretive synthesis of Neanderthal occupation at the northwestern edge of the Pleistocene World. *Journal of World Prehistory* 24(1): 25-97.

White, M. J. & Plunkett, S. 2004. *Miss Layard Excavates: a Palaeolithic site at Foxhall Road, Ipswich, 1903-1905.* Western Academic and Specialist Press Limited, Liverpool.

White, M. J. & Schreve, D. C. 2000. Island Britain - Peninsula Britain: Palaeogeography, Colonisation, and the Lower Palaeolithic Settlement of the British Isles. *Proceedings of the Prehistoric Society* 66: 1-28.

White, R. 1996. On the Evolution of Human Socio-cultural Patterns. In A. Lock & C. R. Peters (eds) *Handbook of Human Symbolic Evolution:* 239-262. Blackwells, Oxford.

Whittaker, J. C. 1994. *Flintknapping: Making and Understanding Stone Tools.* University of Texas Press, Austin.

Winner, L. 1986. *The whale and the reactor : a search for limits in an age of high technology.* University of Chicago Press, Chicago.

Winton, V. 2005. An Investigation of Knapping-skill Development in the Manufacture of Palaeolithic Handaxes. In V. Roux & B. Bril (eds) *Stone knapping: the necessary conditions for a uniquely hominin behaviour:* 109-116. McDonald Institute Monograph, Cambridge.

Wobst, H. M. 2000. Agency in (spite of) material culture. In M.-A. Dobres & J. Robb (eds) *Agency in Archaeology:* 40-50. Routledge, London.

Woodcock, A. 1978. The Palaeolithic in Sussex. In P. L. Drewett (ed.) *Archaeology in Sussex to AD 1500: essays for Eric Holden:* 8-14. Council for British Archaeology, London.

Woodcock, A. 1980. *The Lower and Middle Palaeolithic Archaeology of Sussex*, Unpublished PhD thesis, Department of Archaeology, Leicester University.

Woodcock, A. 1981. *The Lower and Middle Palaeolithic Periods in Sussex.* BAR British Series 94.

Wymer, J. 1968. *Lower Palaeolithic Archaeology in Britain; as represented by the Thames Valley.* John Barker Publishers Ltd., London.

Wymer, J. 1980. The excavation of the Acheulian site at Gaddesden Row. *Bedfordshire Archaeological Journal* 14: 2-4.

Wymer, J. 1982. *The Palaeolithic Age.* Croom Helm Ltd., London.

Wymer, J. 1985. *The Palaeolithic Sites of East Anglia.* Geo Books, Norwich.

Wymer, J. 1999. *The Lower Palaeolithic Occupation of Britain* The Trust for Wessex Archaeology Ltd.

Wynn, T. 1981. The intellegence of Oldowan hominids. *Journal of Human Evolution* 10: 529-541.

Wynn, T. 1995. Handaxe Enigmas. *World Archaeology* 27(1): 10-24.

Wynn, T. 2002. Archaeology and cognitive evolution. *Behavioural and Brain Sciences* 25: 389-438.

Wynn, T. & Coolidge, F. L. 2007. Did a Small but Significant Enhancement in Working Memory Capacity Power the Evolution of Modern Thinking? In P. Mellars, K. Boyle, O. Bar-Yosef & C. B. Stringer (eds) *Rethinking the Human Revolution:* 79-90. MacDonald Institute Monographs, Cambridge.

Wynn, T. & Tierson, F. 1990. Regional Comparison of the Shapes of Later Acheulean Handaxes. *American Anthropologist* 92(1): 73-84.

Yerkes, R. W. & Kardulias, P. N. 1993. Recent Developments in the Analysis of Lithic Artifacts. *Journal of Archaeological Research* 1: 89-119.

Young, D. E. & Bonnichsen, R. 1984. *Understanding Stone Tools: A Cognitive Approach.* University of Maine, Orono.

APPENDIX ONE: THE COMPUTER PROGRAM

In order to analyse the scar patterns on the handaxes selected for study, a computer program was devised to automatically convert a traced image into a data array and analyse this using a two-dimensional fast Fourier transform. This appendix details the computer code used to produce the program, which was encoded using a combination of Octave (Version 3.6.1) and Matlab (Version 2010b).

The first thing that the program is required to do is load the scar pattern trace image. For this thesis, the scar pattern from each handaxe was traced as a black and white, 500x500 pixel jpeg image using Adobe Photoshop CS4. The program converts the image into an array of length and width equal to the size of the image, where areas of the image that are black are recorded as zeros, while white is recorded as a positive value.

f = imread('*image*');	Gets the program to read the selected image file.
[m,n,p] = size(f);	Reads the size of the image array for use later.
f = f(1:1:m,1:1:n);	Sets the array size for the image.
imshow(f, 'Parent', axes);	Displays the image.

The program then pads the array with zeros. This is to obtain a finer sampling of the Fourier transform.

x = round(m/2);	Computes x for padding.
y = round(n/2);	Computes y for padding.
fPad = padarray(f,[x,y],'replicate');	Pads the image array with zeros.

After padding the array, the program then performs a two-dimensional fast Fourier transform on the array. This is based on the following equation for the computation of a one-dimensional fast Fourier transform:

$$X(k) = \sum_{j=1}^{N} x(j)\omega_N^{(j-1)(k-1)}$$

where

$$\omega_N = e^{(-2\pi)/N}$$

is an *N*th root of unity.

This produces a representation of the image as a 'sum of complex exponentials of varying magnitudes, frequencies and phases' (MathWorks n.d.). The natural logarithm of the results is then calculated to aid in the visualisation of the results.

F = fftshift(fft2(fPad));	Performs a 2D Fast Fourier Transform on the array, and shifts it so 0 values are in the centre for visualisation.
F2 = log(abs(F));	Performs the natural logarithm of the absolute values of F.
imshow(F2, [9 10]);	Displays the spectrum of F2.

Before the data can be extracted from the resultant spectrum, the program converts the array from a Cartesian coordinate system into polar coordinates. This places the origin at the centre of the array.

[l,w,p] = size(F2);	Calculates the size of the F2 array.
c = [(l+1)/2,(w+1)/2];	Calculates the centre position for polar coordinates.
[X,Y,val] = find(F2);	Finds the X and Y indices of F2 and also the associated values in the array
[theta,rho] = cart2pol(X-c(1),Y-c(2));	Converts the array from Cartesian to polar coordinates
theta = theta*190/pi;	Converts the values of theta from radians to degrees.

The program then divides the spectrum into a series of 5° segments and calculates the intensity of the spectrum for each of these, using bin counters to compile the data.

```
sum5 = 0;
```

This term creates a bin counter for the 0°-5° segment. The value of the bin is initially set at zero. A bin is created for each 5° segment between 0° and 180°.

```
M = length(theta);
for k=1:M
   th = theta(k);
   if th>=0 && th<5
      if val(k)>=9 && val(k)<=10
      sum5 = val(k)+sum5;
      end
   end
end
```

This term calculates the value of each cell within the array and assigns it to a bin based on which segment it resides within, in this case the 0°-5° bin.

```
bins = [sum5 sum10 sum15…]
```

This compiles the bin counters and their data in preparation for it to be saved as a text file output.

The computer program was used to analyse scar patterns from both faces of each handaxe within all four of the assemblages studied as part of this thesis. Once the data was saved as a text file output it was then compiled into a complete dataset along with the data from the other handaxes using Microsoft Excel. These datasets can be found on the Supplementary Data disc at the end of this volume.

SUPPLEMENTARY DATA

At the rear of this volume there is a disc containing supplementary data to this thesis, the contents of which are listed here:

3D Data:

This contains all the datasets pertaining to the 3D analysis discussed in Chapter Seven of this volume. It is subdivided as follows:

- Aspect Datasets – containing an Excel dataset for the combined aspect data from all of the sites. In addition, datasets from each of the following assemblages are contained in separate folders:
    - Boxgrove
    - Caddington
    - Experimental
    - Foxhall Road
- Slope Datasets – again, containing an Excel dataset for the combined slope data from all of the sites, as well as datasets from each of the following assemblages in separate folders:
    - Boxgrove
    - Caddington
    - Experimental
    - Foxhall Road

Photographs:

Photographs of all of the handaxes that have been studied can be found within this folder. Images representing both sides of each handaxe are present and all photographs are in jpeg format. The folder is subdivided as follows:

- Boxgrove Unit 4_3
- Boxgrove Unit 4u
- Caddington Handaxes
- Experimental Handaxes

- Foxhall Road

Scar Pattern Data

All of the Excel datasets pertaining to the scar pattern analysis discussed within Chapter Eight can be found within this folder. It is subdivided as follows:

- Boxgrove
- Caddington
- Experimental
- Foxhall Road

An additional dataset containing the relevant data for all of the assemblages combined can be found in the main folder.

Scar Pattern Traces

Finally, scar pattern traces from all of the handaxes studied can be found within this folder. As with the photographs of the handaxes, an trace from both sides of each handaxe is present and all of the images are in jpeg format. The folder is subdivided as follows:

- Caddington Traces
- Experimental Traces
- Foxhall Road Traces
- Unit 3-4 Traces
- Unit 4u Traces